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SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : A. 5. 1. 3 Italie

EVOLUTION ET PERSPECTIVES DE LA REGLEMENTATION DES MINES PAR RAPPORT AUX CONDITIONS TECHNIQUES ET AUX EXIGENCES SOCIALES DES PAYS EN VOIE DE DEVELOPPEMENT

Par Pietro GASPARRI,
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Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

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EVOLUTION ET PERSPECTIVES DE LA REGLEMENTATION DES MINES PAR RAPPORT AUX CONDITIONS TECHNIQUES ET AUX EXIGENCES SOCIALES DES PAYS EN VOIE DE DEVELOPPEMENT

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1°)- Considérations préliminaires.

2°)- Caractéristiques des pays en voie de développement par rapport aux problèmes de la législation minière.

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8°)- Opportunité de règles relatives à la nationalité des entreprises concessionnaires.

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Pietro G A S P A R R I
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1°) Considérations préliminaires

Une étude sur le régime juridique de recherche et d'exploitation des mines dans les pays en voie de développement peut viser à deux buts complémentaires l'un à l'autre: le premier c'est de rechercher et de classifier les systèmes législatifs actuellement en vigueur dans lesdits pays, le second c'est d'établir les lignes d'un système législatif aussi approprié que possible aux exigences des pays intéressés dans la délicate phase historique qu'ils sont en train de traverser.-

Pour atteindre le premier but il faut un travail de recherches très vastes qui ne peut rèsulter que de la somme et de la coordination des efforts individuels; et certes ceci ne pourrait trouver de place dans le bref espace réservé à mon exposé.- Toutefois je pense remplir mon devoir en me bornant à quelques considérations visant à contribuer à la réalisation du second but.- Il est évident qu'un travail de ce genre, considéré en soi, ne peut prétendre à être complet et définitif, mais qu'il se présente seulement comme le point de départ de recherches et de discussions ultérieures.-

2°) Caractéristiques des pays en voie de développement par rapport aux problèmes de la législation minière

Pour tracer les lignes d'un droit minier adapté aux "pays en voie de développement" il faut tout d'abord préciser quelles sont les caractéristiques de ces pays.- A savoir: ces caractéristiques qui ressortent sous le profil de l'activité minière.- A cet effet il me semble que l'on peut tomber d'accord sur les points suivants:

a)- Les pays en voie de développement ont en général des territoires faiblement peuplés ou même dépeuplés, désertiques, recouverts de savanes ou de forêts, peu connus du point de vue géologique et où le travail de recherche, dans ses différentes phases, et d'exploitation des gisements miniers, offre des difficultés et des risques d'une importance notable.-

b)- Les pays en voie de développement ont en général un régime foncier qui n'est pas extrêmement clair et évolué; et un système de relèvements et d'enregistrements cadastraux embryonnaires ou franchement inexistants.-

c)- Les pays en question ont un èquipement èconomique et technique en phase de formation et qui est de toute façon peu vaste et consolidé.- En particulier il leur manque généralement un système de crèdit efficient; il y a peu de centres d'études et d'informations, tel que les instituts universitaires et des corps d'ingènieurs miniers dont disposent les Etats à l'économie développée depuis longtemps.-

d)- Dans les pays en voie de développement il est fondamentalement nécessaire de former une classe dirigeante douée d'une préparation technique adéquate et d'expériences financiaires correspondantes, il faut également y former une classe de travailleurs convenablement préparés et spécialisés.-

3°) Préférence d'un système qui réserve à l'Etat ou aux Organismes publics la propriété des gisements miniers

Ceci étant posé, en tout premier lieu il semble déconseillable d'adopter un système lègislatif laissant au propriétaire de la superficie la proprété illimitée du sous-sol, y-compris les gisements miniers.- Tout cela pour différentes raisons, et en particulier:

a)- parce que les confins de la propriété peuvent ne pas être exactement déterminables;

b)- parce que l'ampleur de la propriété peut être inadéquate, par défaut ou par excès, à l'installation rationnelle de une entreprise minière;

c)- parce que probablement le propriétaire de la superficie manque de moyens et d'aptitudes nécessaires à la recherche et à l'exploitation des gisements miniers.-

D'ailleurs en refusant ces systèmes et en adoptant un système de propriété publique (de l'état, de la région, de la province, etc.) des gisements, les Pays en voie de développement ne feront que se rallier au régime minier adopté depuis longtemps dans les pays à l'économie développée.-

4°) Divers systèmes de règlementation de l'activité minière

Le système de la propriété publique des gisements miniers est compatible avec trois systèmes divers de règlementation de l'activité minière (recherche et exploitation):

a)- celui qui rèserve l'exercice de ces activités de façon exclusive et sans possibilité de dérogation à l'Etat ou à d'autres organismes publics;

b)- celui d'après lequel ces activités peuvent être exercées seulement par des particuliers, mais en se fondant sur des permis ou sur des concessions de la part de l'Etat ou d'autres Organismes publics propriétaires des gisements;

c)- celui selon lequel les deux régimes d'activité minière sont adoptables alternativement ou envisagés de façon diverse; par exemple en réservant à la communanté la recherche et l'exploitation dans des zones données ou bien de substances données, tout en consentant et en rendant obligatoire pour les autres zones et les autres substances l'utilisation de l'initiative privée moyennant des permis ou des concessions.

Il n'est pas conseillable aux Etats en voie de développement d'adopter rigoureusement le premier système.- Il présuppose une structure bureaucratique, technique et financiaire que les communautés de formation récente ne sont pas toujours en mesure de se donner dans un bref délai; et elle exclue éventuellement les apports utiles de l'initiative privée, même étrangère.- Il est vrai, d'autre part, que les

gouvernements des communautés en question peuvent avoir ou se procurer des moyens de recherche et d'exploitation dont leurs membres, individuellement ou en s'associant, ne disposent pas; alors qu'il serait imprudent pour eux de s'en remettre totalement à l'initiative privée étranère.-

En conclusion et à condition de les adapter opportunément aux situations de chaque pays, il semble que soient préférables les systèmes mixtes dans lesquels l'initiative publique et l'initiative privée peuvent s'intégrer réciproquement.-

5°) Règlementation de la prospection minière

Etant donné que les territoires des pays intéressés sont peu connus sous l'aspect géologique et géophysique, le travail de prospection mérite d'être facilité au maximum.- Il faudra donc toujours un permis visant à donner aux prospecteurs le droit de pénétrer dans les fonds d'autrui et d'y exécuter (sauf indemnisation pour d'éventuels dommages) les reliefs et les expérimentations nécessaires.- Toutefois il ne semble pas opportun d'assigner aux prospecteurs des zones en exclusivité.- Néanmoins les autorités compétentes devraient avoir le pouvoir de refuser le permis de prospection dans les zones où opèrent déjà d'autres prospecteurs afin de favoriser l'extension de la recherche à des zones qui sinon resteraient négligées à cause de leur éloignement des centres et des difficultés qu'elles offrent.-

6°) Règlementation de la recherche en profondeur

Le travail de recherche en profondeur, nécessitant la perforation de puits ou le creusement de galeries ou d'autres travaux de terrassement, doit être sujet à des permis avec l'autorisation des zones en exclusivité.- Le chercheur doit avoir le droit de s'approprier des minéraux qu'il a trouvés

si ce n'est que pour expérimenter leur rendement industriel.- En somme la seconde phase de la recherche, pour laquelle il faudrait fixer un terme avec possibilité de prorogation, devrait fonctionner comme une espèce de concession provisoire.-

Il semble juste de donner la préférence, en faisant lesdites concessions provisoires, aux entreprises qui ont éxécuté des travaux de prospection dans la zone envisagée, et parmi elles à celles qui ont obtenu les résultats les meilleurs.-

Il semble conseillable de menacer de déchéance les chercheurs négligents qui se serviraient du permis seulement pour accaparer les zones, sans se soucier de créer, autant qu'il est possible, les présuppositions d'une exploitation rationnelle.-

7°) Règlementation de la concession d'exploitation

Par contre il faut en quelque manière garantir la concession d'exploitation à très long délai au chercheur qui l'ait bien méritée.- En somme il est conseillable de réserver aux chercheurs une priorité absolue pour l'attribution du droit d'exploitation.- Seulement lorsque le chercheur a été frappé de déchéance ou a fait un acte explicite de renonciation il est alors justifié de soumettre à un examen comparatif la demande éventuelle d'autres aspirants à la concession.- La garantie en question constitue une compensation adéquate aux frais énormes qu'entraîne la recherche en profondeur.-

8°) Opportunité de règles relatives à la nationalité des entreprises concessionnaires

L'apport de l'initiative, du capital et de l'expérience technique étrangère peut être extrêmement utile aux pays en voie de développement.- Aussi est-il déconseillable d'insérer dans la législation des pays en question des dispositions visant à réserver les activités minières seulement aux opérateurs locaux. Il faut, par contre, éviter que l'intervention d'entreprises

étrangères puisse aboutir à des situations de colonialisme économique substituant le colonialisme politique dont plusieurs de ces pays viennent de sortir.-

Aussi ne semble-t-il pas contraire aux intérêts des dits pays d'adopter un système de dispositions visant à éviter que leurs ressources minières soient monopolisées en fait et en droit par une entreprise ou par des entreprises d'un seul pays étranger.- En d'autres termes il est souhaitable d'adopter des critères de limitation afin de distribuer convenablement les concessions à des entreprises étrangères par rapport à leur nationalité.-

Et ce serait un juste principe de conditionner les concession faites aux entreprises étrangères à des clauses les obligeant à embaucher et à former, dans une proportion donnée croissant progressivement, la main d'oeuvre disponible sur place.-

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A.5.1

Austria

GEOSCIENCE EXPLORATION NEEDS A TWO-FOLD BASE

By H. KUPFER, Prof., Ph.D.,
Director Geological Survey of Austria

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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A.5.1.

Geoscience Exploration Needs
A Two-Fold Base.

by H. Kupfer, Prof., Ph.D., Director
Geological Survey of Austria.

The author was engaged in various phases of oil exploration from 1927 - 1947 in the Far East and Europe; and since he has been in contact with many geologists from Central Europe, who were in one way or the other connected with the exploration activities, which since 1950, have been going on in various continents.

In the following he outlines his opinion, that especially in areas where geoscience exploration has not yet resulted in a definite positive evaluation and where a broad local basis for working out field data along the most modern lines is not yet established, a double background for geosciences-exploration is desirable from an economical and also from a scientific point of view. One basis is formed by the field parties operating in areas, the evaluation and exploration of which is the aim of their activities. A second and equally important basis should be the laboratories preferably of the countries, from where the members of the field parties are recruited. Research work is essential on collected sample material, but this could be done only within the shpere of laboratory scientists, who have at hand personnel and equipment well versed in all the details and technicalities of modern and historical methods. The fact that firstly such laboratory units cannot easily be transferred without loss of capacity to far away locations, likewise secondly, the fact that moving such laboratory units would be very costly if the positive results of the exploration is not established and thirdly that laboratory units in their well based position in the home country could serve as backgrounds or home platforms to more than one exploration enterprise, makes it strongly advisable, to lay out geoscience explorations, at least in its early stages in such a way, that a carefully tuned interplay between field unit and home laboratory unit is secured.

Some remarks intended to substantiate the above ideas are submitted in the following.

Geological field work in the early years of this century consisted in "mapping" i.e. plotting on the plane table or in the sketch book what the observer has seen and measured; then, usually already on the spot, an idea could be given, whether an area seemed to be attractive. As practically no more such easily assessable structures are left, geology has to look today for possibilities mostly deep below the surface. A careful examination of surface samples as to its micro-content, mineral associations and other facts not easily established on the spot, is therefore necessary. Laboratories carrying out the break down of samples in a modern way started working in the thirties in areas, where production had been established on structures found by classical methods; such laboratories are of course missing in areas where so far no production exists.

Ore-exploration was formerly mapping and sampling of ore-seams; the interest was centered on those minerals, which were known to yield say Pb, Sn and which

in most cases could be identified on the spot. Elements today of interest as e.g. cadmium, germanium, indium are not to be traced by simple field or classic laboratory methods but require highly specialised laboratory techniques, e.g. spectrogrammetry, methods which certainly cannot be put into effective working under rough conditions.

Seismic work for subsurface exploration at first also used as a tool on the spot has become more and more specialized; its value as tool on the spot of course remains, but careful reinterpretations, sometimes several times over by workers independent of the locality, becomes an important additional possibility, which likewise should not be linked with field conditions.

Soil research today widens into micro-biology, geochemistry, local climatology, again of course starting from modern field observations; but these new sections are often beyond the realm of the field-worker or field-laboratory.

Examples to demonstrate similar tendencies of development could be added. They all point to two facts:

firstly, that there is a stage in geoscience exploration when the value of the prospect is not yet settled during which it does not seem advisable, to shift complicated laboratory methods too far into the zone of exploration; on the contrary in this case it seems advisable to use home laboratories as the basis for highly specialised laboratory-work;

secondly, that exploration work in far away countries, as usually carried out today, should be linked up more closely with "home methods" in order to obtain fully worked-out modern results. This of course, involves a consideration of the financial side, because, next to the costs of the field parties, the cost for additional costs in specialized home-laboratories should be considered as an essential component of any overall exploration budget.

It will of course, be necessary to take into account the specific aim of each exploration before deciding which sections of the laboratory work would have to be carried out on the spot and which of the more specialized work should be done "at home". No strict rules are recommended; but the aim should be that at a minimum cost a maximum amount of normal and highly specialized laboratory results should be put quickly at the disposal of the organising center of the field party.

The present highly developed methods of transportation will reduce the time factor, of course to be calculated by conveying samples from the field-staff to home-laboratory-staff with a minimum of risk, if plotted against the total time of the field-work and laboratory-work necessary.

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Agenda Item : A.5.1.3

United States of America

LEGISLATIVE CHOICES IN THE DEVELOPMENT OF MINERAL RESOURCES

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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LEGISLATIVE CHOICES IN THE DEVELOPMENT OF MINERAL RESOURCES

Northcutt Ely, Attorney, Ely, Duncan and Bennett, Washington, D. C.

A. Introduction

1. A nation's mineral wealth, if it remains unknown or undeveloped, contributes no more to the well-being of the people who live above it than if the earth were barren. The ultimate objective of the good mineral development law is thus to put the nation's mineral resources to work for its people. This is not done by hoarding minerals in the ground unused, but by facilitating their wise use. "Wise use" is the true meaning of conservation, and therefore a sound mineral development law must of necessity be a mineral conservation law.

2. A less developed nation needs low cost minerals and fuel for use by its people; it needs the revenues which can be generated by sale of its mineral production to support its government, as well as to provide its economy with purchasing power in foreign markets; it needs capital and "know-how" to find, produce, and market its minerals; and it needs employment opportunities and technical training for its nationals to enable them to develop and administer mineral resources.

3. Most of the less developed countries must attract foreign capital for mineral exploration. Even in more mature countries it is difficult to generate sufficient capital by internal taxation to finance the hazardous gambles which characterize the exploration and development of minerals. The amount of capital required for the mineral exploration of any significant area is exceedingly large. The risk of losing the investment is very high. Many examples can be cited of great expenditures by companies that failed to find a single worthwhile prospect. In Turkey, for instance, a company recently spent $20 million in drilling exploratory wells and withdrew without finding oil in commercial quantities. On a worldwide average, only one exploratory well in ten strikes oil in quantities which justify production, even though this average includes the favorable areas in the mid-East and Libya where the ratio is much better.

4. In a single nation the ratio may be twenty or thirty failures to each discovery. Even if a discovery is made, the capital required for development and exploitation is larger still, as a few examples of success in finding oil will illustrate. The successful search for oil in western Canada shows this balance sheet: At the end of more than ten years of production, the total investment exceeded the total value of all oil produced by more than a billion dollars. It will take fifteen years of production for the initial investment to be recovered. In the Rocky Mountain area of the United States there have been similar results. After a dozen years of successful operation, the total investment still exceeds the total value of production by more than a billion dollars.

5. The risks of loss usually prevent the less-developed nation from investing its own revenues in the search for and development of its minerals. Public officials are understandably reluctant to take the responsibility for spending tax money in drilling wildcat wells or undertaking expensive geophysical operations or sinking mining shafts in doubtful territory, where the odds at best are ten to one against

finding commercial deposits, and where, even if the search succeeds, an amount many times the original exploratory investment must be found and spent for development of the oil field or ore body, and construction of production facilities and transportation systems, refineries, and pipelines to carry the minerals to market. Even in the event of success, few young nations can contemplate a dozen subsequent years of heavy deficits in the development of these resources, such as the experience in western Canada and the Rocky Mountain area of the United States suggests. The relatively few state-owned companies that have succeeded in the risky exploration phase embarked upon it armed with substantial capital, previously accumulated, and were in position to diversify their risks. Lacking such previously acquired capital, it may not be wise or even possible for a less developed nation to borrow money for mineral exploration. In several nations, the initial decision to exclude private capital has been modified after finding that the public funds available for mineral development have not been commensurate with requirements, and the resulting necessity for importation of minerals from foreign countries has added to the nation's foreign exchange problems.

6. The company that risks the savings of its investors in the search for minerals knows that if the search fails, as it probably will, the loss will fall exclusively on it, not on the government. It is entitled to assurance that in the event of success it will not be second-guessed, and the reward that it has earned be expropriated.

7. Our objective is thus to find a legislative formula which will bring about the maximum ultimate recovery of a nation's minerals, under conditions which will yield maximum benefits to its people while affording fair treatment to those who risk their capital to bring this development about.

8. In constructing our formula we can assume, as a starting point, that the central government, and not the surface owner, owns and controls the mineral estate. This is the law in most parts of the world, outside the United States, although in some nations the title to minerals is in a provincial or state government. Thus the mining law is the pronouncement of the government both as sovereign lawmaker and as negotiating proprietor. As sovereign the government can enact and enforce such laws as it pleases, subject only to restrictions self-imposed by its constitution and to such limitations as observance of international law may necessitate. But as a proprietor it may find that these very laws defeat their own objectives if they frighten away the foreign capital which they must attract if the latent mineral resources of the nation are to be developed.

9. In a sense, both the host government and the foreigner who risks money in its mineral development are trustees of the nation's mineral resources. In another sense, they are partners in meeting the competition of other mineral-producing nations in the world market. In still another sense, less frequently articulated, they share a common obligation to the consumers of the world that the minerals upon which all are dependent shall be made available for use at reasonable prices over the longest possible period.

10. In deciding how to draft a successful law dealing with the forces which we have just discussed, the task can be broken down into about a half-dozen major chapters. Perhaps the most orderly procedure is to take up these subjects in the logical order of organization of a statute, in which we will see, as we go along, the interrelationship of these problems, some great, some small.

B. Scope of the law, its relation to other laws, and its administration

11. Starting with the premise that the sovereign owns the minerals and that the law that we are drafting will state the terms upon which those minerals can be

sought and produced, the first considerations are these:

12. What minerals shall be covered? The comments in this paper apply generally to oil and gas, and also to the hard minerals, because the same principles control them all. But the details differ to such an extent that it is desirable that separate statutes deal with petroleum and associated minerals on the one hand, and solid minerals on the other, although they may be administered by a common agency.

13. Who shall be eligible to search for these minerals? Foreign governments and their governmental corporations should not be eligible unless they are made so by special acts of parliament, rather than the general mineral laws. The reasons need no discussion. But otherwise it is good business for the host nation to open the door to nationals of all nations who have the required character, technical competence, and financial means to develop the resources on terms satisfactory to the nation. If the law's purpose is to attract capital and talent, it should not defeat that purpose by excluding those eligible to furnish it. We shall discuss later special problems relating to foreign corporations.

14. What other existing laws limit our freedom in drafting a mining code? Aside from constitutional limitations, some of the things an investor must know are likely to be contained in the tax laws, or the foreign investment law, or perhaps in a treaty which requires preferential treatment for some other nation, for example, with respect to repatriation of profits or in restriction of markets for production.

15. Another important preliminary question must be answered: Who shall administer the mineral laws? With whom shall the investor deal? This is crucial. The best-written law is futile if not administered in a clear-cut line of authority by competent and honest men who are adequately paid. It is wise to dedicate mineral revenues first to the payment of good salaries to good men, before paying the balance to the nation's general treasury. Treat money so dedicated as seed-corn, and it will pay for itself many times over.

16. Let us keep the statute itself simple, as nearly as possible in the generalized form of a constitution, and let it delegate to the administrator the power to fill in the details by his regulations and orders.

C. <u>The "concession" system</u>

17. Two kinds of mineral laws appear on the books: general statutes, under which all contracts with individuals are made, and special laws, each ratifying a single contract. The best plan is the former, a general nondiscriminatory statute which offers the same terms to everyone and attracts the maximum of competitive effort.

18. Let the general statute authorize contracts between the government and the mining or petroleum company, which will define the rights and obligations of both parties, consistently with the boundaries for negotiation fixed in the statute. In this discussion such contracts, of whatever type, are referred to as concessions and those who hold them as concessionaires, simply because these terms are common coinage.

19. There are three stages that a mineral venture must pass through on the way to ultimate success. These are reconnaissance, exploration, and production. (Discussion of the phases that follow if production is successful -- i.e., refining, transportation, and sales, must be postponed to another day, as outside the scope of the present discussion. These will be mentioned only in passing. Indeed space limitations preclude detailed treatment of even the initial phases of the development process.) It is sensible, therefore, to authorize three different successive types of mineral concessions, although the three stages can be combined in one

document. The choice of labels is unimportant so long as the differencies in function are recognized.

Reconnaissance permits.

20. The proper function of a reconnaissance permit is to confer upon the holder a non-exclusive right, for a limited time, to examine the area covered by the permit in order to determine whether or not to proceed further. The permittee needs the right to examine structures and ore bodies, take samples, utilize geophysical and other scientific devices, and perform any other work usual in the preliminary examination of potential petroleum or mining areas. A single reconnaissance permit may properly include as large an area as the applicant identifies in his application, except areas which are within those covered by exploration licenses or exploitation concessions (discussed later). He should have access to maps and nonconfidential data developed by the government, on payment of reasonable charges for such services. The permit does not confer any right to make permanent installations or to produce minerals for use or sale. It does not confer any preferential or other right to the issuance of an exploration license or an exploitation concession, and the government should not be precluded from granting such a license or concession by the existence of a reconnaissance permit covering the same area. The permit is a sort of an entry visa, and the more of these that are applied for and used the better-known will the nation's resources become, and the greater the probability will be that competition for them will develop. Fees should be nominal. The true consideration is full disclosure to the government of the information discovered in the reconnaissance. This ought to remain confidential if the permittee proceeds further and applies for an exploration license.

Exploration licenses.

21. The next step, exploration, is usually a very expensive stage of the operation, while producing little revenue. One who undertakes it must have security of tenure. The exploration license thus must confer upon the holder the exclusive right, within the areas specified in the license, to explore and prospect for the minerals covered by the code. It should permit the use of any exploration method, including the drilling of wells, sinking of shafts, driving of tunnels, making trial runs of materials through treatment plants, and the construction of works and the performance of operations, short of commercial production, as may be necessary to enable the licensee to decide whether or not to apply for an exploitation concession. If production is obtained during the process, perhaps by drilling of additional wells to determine the limits of an oil field after the initial discovery, it can be marketed under a temporary production license. The license must define the area covered, because the right is exclusive. The size of the area, per license, is a matter of policy. Full reports should be filed but should remain confidential. They are the licensee's work product, obtained at great expense, and should not be given to a competitor.

22. The essential point, from the state's viewpoint, is to assure vigorous and diligent exploration. There are several devices that can be used to promote this. One is to authorize the administrator to agree with the concessionaire on a program of required expenditure or work. Another is to require payment of surface rentals, on a gradually increasing scale, on the areas that are not developed, so that it becomes expensive to hold them idle. The purpose of the surface tax is not to exact revenue; this is wholly secondary to the purpose of spurring activity. Another device is to limit the duration of the license to a few years and authorize its renewal only on condition that the licensee relinquish a stated percentage of the area on each renewal, unless he has discovered minerals and qualified for and obtained a long-term exploitation concession.

23. From the concessionaire's standpoint, these points are essential:

(i) The right to occupy the licensed area must be exclusive.

(ii) The exploration license must guarantee the licensee the right to obtain an exploitation concession if he discovers minerals. The terms of the exploration concession to which he may convert his exploration license may, if he desires, be annexed to the license, with the assurance that the terms of the exploitation concession which he earns shall not be amended to his disadvantage.

(iii) If the exploration is unsuccessful, the licensee must have the right to salvage and repatriate his equipment. Second only to the importance of the concessionaire's knowing how he can get into a country to look for minerals is the knowledge of how he can get his equipment out again if he does not find them.

Exploitation concessions.

24. An exploitation concession essentially confers upon the holder the exclusive long-term right, within the area covered by the concession, to develop oil fields or mineral bodies, to produce for market, to refine or beneficiate the minerals produced, to export and sell them in their original or refined form, to select the buyer and means of transportation to market, to negotiate the terms of sale, and to receive payment for them. It carries with it greatly increased financial burdens -- the necessity to develop the oil field or ore body discovered, build gathering systems and provide transportation to market, etc.

25. As to the area which may be included within an exploitation concession as compared to that included within an exploration license, the question is one of policy to which many factors are relevant. If the area in the exploration license is small, there are fewer reasons to require relinquishment of part of it, or as much of it, on conversion to an exploitation concession, than if the licensed area is very large. As to whether or not discovery of minerals in commercial quantities shall be prerequisite to issuance of an exploitation concession, the weight of precendent is in the affirmative, treating the exploitation right as a reward for discovery. But a nation may find very good reasons to issue an exploitation concession to a company bold enough to take on heavy development obligations under it befor it has verified the existence of minerals in commercial quantities.

26. It is useful to include all three phases -- reconnaissance, exploration, and exploitation -- in one concession contract, separating the successive stages into corresponding titles and plainly describing the events which will "trigger" the change in relationship from one status to the other.

D. The principles that ought to control the terms of a concession

27. As to the terms of the concession, particularly an exploitation concession, the parties must each recognize the legitimate objectives of the other. The state rightly seeks the maximum ultimate recovery of an irreplaceable resource under conditions which will be of maximum usefulness to its economy. The concessionaire seeks the maximum financial return upon his investment, and rightly believes that the amount of that return should reflect the very high degree of risk which the investment entailed.

28. But there is one principle that ought to govern the thinking of both the state and its concessionaire in bargaining about their respective shares in the mineral wealth that both of them hope will be found and produced. The common purpose ought to be to bring about the maximum ultimate recovery of the mineral resource and to market that production at prices which will assure its entry into

the world market at competitive but profitable levels. This requires some mutual adjustments. If the concession has a short term, the pressure is on the concessionaire to get out all he can, as cheaply as possible, even by production methods that leave a large part of the resource permanently unrecoverable. To the extent that he is assured long tenure that pressure is lessened. On the other hand, the two-fold curse of many mining countries is, first, the speculator who gets control of a mining claim or "denouncement" merely for the purpose of holding up development of a larger area until he is bought out, and, second, the concessionaire who has control of a second ore deposit in another country that he prefers to produce while holding the first as inactive as possible. To some degree these problems can be met in the statute's requirements for development expenditures, previously discussed, and in its financial provisions, to which we now turn.

E. Financial matters

29. The state's financial gain from the development of its mineral wealth can take one or more of several forms. Some of these, and the reasons which should control their selection or rejection, are considered below. Simply to catalog them underscores what was said earlier, that the attraction of a new mineral industry to an undeveloped country may be affected less by the content of the mineral laws than by what is found in other controlling statutes.

30. Import and export duties on equipment. These should be rejected. It is to the nation's interest to attract all the tools that are obtainable, on the assurance that when they have served their purpose they can be taken home again.

31. Bonuses. These are lump sum payments obtainable on competitive bidding for exploration licenses or exploitation concessions in favorable areas. Manifestly their availability is in proportion to the attractiveness of the area.

32. Surface taxes. Their proper purpose is not to obtain revenue, but to penalize idleness and reward diligence in looking for and producing minerals. For that reason they should apply only to areas on which no development has been attempted, and should be increased by a pre-set scale in successive periods of years. If development is diligent, the development expenditure may stand in the place of surface taxes.

33. Annual lump-sum minimum payments. These are negotiable.

34. Royalties. These are percentages of the gross value of the product, payable in cash or as a share of production, "in kind." The rates are negotiable, but it should be remembered that royalties are exactions from gross revenue, not net income, and hence may be payable even if the concession operates at a loss.

35. Export taxes. These tend to defeat their purpose by burdening the country's production in competition with that of other nations.

36. Ad valorem taxes. Mining investments, like investments in public utilities, are characteristically very heavy, per dollar of revenue produced; unlike public utilities, however, the rate of return on that investment cannot be guaranteed. To the contrary, mineral prices are characteristically volatile, and even if prices remain stable the amortization of the investment is dependent upon the size of the mineral deposit, which may be a highly uncertain factor. Mining ventures are an inviting target for ad valorem taxation, because the target is so large and visible but they are peculiarly susceptible to the anemia which fixed-level taxation can produce in an industry so highly dependent on variables that are beyond the control of management. For this reason, the profit-sharing device, to which we will come in a moment, is an attractive substitute.

37. Income taxes. The corporate income tax, of progressively increasing rates, and its concomitant, the tax on dividends, are almost universal; but there is a refinement available, to which we now turn.

38. Profit-sharing agreements. There is a growing tendency in mineral legislation toward profit-sharing agreements between the state and the concessionaire as a substitute for all forms of taxation. The simplest device is to state a tax at the agreed rate on net income, declare that this replaces all other taxes of every description, and to provide that royalties or agreed minimum annual payments shall be credited against that tax, or, if in excess of the tax, credited against the tax otherwise payable in later years. This automatically puts the nation and the producer in step toward what should be their common objective, marketing the maximum ultimate recovery at the best price obtainable.

39. The profit-sharing device also provides a vehicle for attaining an objective which nearly all undeveloped countries nourish: the hope that domestic capital can be found to participate to some extent in the nation's mineral development so that it will not be wholly dependent upon foreigners. A common proposal is that the concessionaire must be a domestic corporation, and that a majority or a stated per cent of its stock be locally owned. This usually defeats its purpose, for two reasons: First, to the extent that such a provision excludes foreign capital, mineral development is retarded. If this were not so, the simple solution would be to prohibit foreign investments altogether. Where this latter extreme has been reached, more of the nation's minerals have indeed remained safe in the ground, but the people have had correspondingly small benefit from them. Second, the tax laws of the concessionaire's country of origin may require that, in order for such a company to offset losses in one country against profits in another in the calculation of income taxes payable at home, it shall operate in both countries as a single corporation, or, if operating through separate corporations, that they be wholly owned by the taxpayer.

40. But there is a solution. It is justifiable for the state, speaking as proprietor as well as tax-collector, to provide that if a profit-sharing agreement is negotiated, displacing all taxes, more favorable terms will be granted in such an agreement to concessionaires who facilitate participation in the venture by local capital than to those who do not. Participation does not necessarily mean ownership of stock of the concessionaire. It can mean an association between two corporations, one foreign owned, one domestically owned.

41. Some other financial problems require mention. One of the most serious is the concessionaire's right to sell his production in any market for any currency, and convert it into the currency of his choice; and the related right to repatriate profits freely, and capital as well in the event of liquidation or sale of the venture. To the extent that this freedom is restricted, by whatever laws -- whether the mineral laws, investment laws, foreign exchange controls, or "zone" accords with favored nations -- the nation restricts the competitive attractiveness of its minerals to the investor.

42. Another problem is the right of surrender. No concessionaire will voluntarily surrender a profitable concession, but if he cannot make a go of it, he should not only be permitted, but encouraged, to take his equipment and leave (provided that debts are paid and formations protected), so that a successor can be placed in possession of the area.

43. Another is the problem of pricing of mineral production for the calculation of royalties or of the state's agreed percentage of profits. Where production is sold in the open competitive market, the impersonal market solves the problem; both the state and the concessionaire must take the bitter with the sweet, in simultaneous doses. But where the concessionaire consumes the minerals, in one stage in an integrated operation, or controls the world market in some degree, or sells to an

affiliated company at a price not negotiated at "arm's length," there is the possibility of trouble. Both sides, therefore, have an interest in plainly stating criteria of values and providing standards of disclosure in the concession agreement, to avoid such misunderstandings. The greater the degree of candid exchange of information between the concessionaire and the government, the less likely these collisions will become.

F. Arbitration and judicial review

44. A sensitive subject is the procedure for settlement of disputes between the sovereign and the concessionaire. Differences and disagreements are bound to arise. Exploitation concessions usually operate long after the life expectancies of the men who negotiated them, and under conditions that no one could have foreseen. Most of the necessary adjustments are made amicably, most of the disagreements are settled. But these accommodations are facilitated if the parties know that both of them have recourse to an impartial tribunal to resolve a dispute that cannot be settled by agreement. Moreover, there is a natural fear on the part of investors that political upheavals in a distant land may result in the expropriation of their investment. Their willingness to invest is directly proportional to their confidence in the sovereign's fidelity to their agreement and in availability of an independent judiciary to enforce that agreement, irrespective of political changes.

45. A new nation, by hypothesis, has not yet had time to establish its reputation for honoring its contracts, nor time to demonstrate the independence of its judicial system. But it is understandably reluctant about conceding either of these things. This is no reproach to the new nation, for the doctrine of sovereign immunity is a shield behind which some very old nations have sometimes retreated when sued for the violation of their agreements, even though the courts in which they refused to litigate were their own.

46. Two alternative devices are available for solving this delicate problem. One is a provision in the statute and concession to authorize international arbitration of major issues between the sovereign and a foreign company, or company whose stock is owned by foreigners. By "international arbitration" is meant the selection of a sole arbitrator, or the neutral arbitrator if each party also appoints one, from a nation which is foreign to both disputants; or, failing agreement upon such a person, his appointment by some recognized international judicial agency, such as the Permanent Court of International Justice. Under this procedure the award is enforceable as a judgment.

47. Another device is provision in the statute for creation of a special court or board of concession appeals, which, although appointed by the sovereign, is made up of distinguished foreign jurists whose names are known before the concession is signed.

48. There is no perfect solution for the problem of resolving disagreements under a mineral concession, just as there is no perfect way of writing an agreement which will be forever free of misunderstanding. But the sensible thing is to recognize that a long-term mineral development agreement, international in the sense that it is a device to enlist the resources of one nation in the development of the resources of another, requires international judicial machinery of some kind to enable it to function equitably. Such an agreement is peculiarly susceptible to the generation of differences in viewpoint. These arise in the beginning out of difficulties of language in the expression of a "meeting of the minds," and later in the application of the agreement to conditions that may change drastically as the very consequence of its successful operation, resulting sometimes in great changes in the host nation's economy, its way of life, and its politics.

G. Conclusion

49. The successful mineral laws of the world -- we have examined those of over a hundred jurisdictions -- all apply certain principles in common, irrespective of details.

50. The first principle is a fair allocation of risk and profit. The risk, in all cases, is upon whomsoever provides the capital. The investor will risk his savings only if there is a possibility of profit commensurate with the risk, which in the mineral industries is very great. On the other hand, the state is acting as guardian of an irreplaceable resource and must insist that that resource make the maximum contribution to the nation's economy, present and future.

51. The state is usually both proprietor and sovereign in the areas of the world we are now considering. Where one side to a bargain is both the law giver and the owner of the property to be developed, its power is so great that the only restraint upon it may be self-restraint, and the duty to exercise self-restraint is correspondingly increased. Conversely, where the technical know-how, the financial resources necessary for mineral development, and perhaps the access to markets, are in the hands of the concessionaire and not the government, it too is a guardian of the interests of the state as well as its own interests, and owes a corresponding duty to exercise its economic power honorably.

52. These principles, although sometimes differently stated, are recognizable in every system of law under which the mineral resources of the world are being developed successfully. This pattern is reflected in the maxim of the Roman law, "pacta sunt servanda;" in that of the common law which describes a contract as "the law of the parties;" in the Muslim law, "Muslims are bound by their stipulations;" and is carried over into the international law which every civilized community recognizes. This is not to say that a state does not possess rights of nationalization, but a state defeats its own purposes if these sovereign powers are exercised otherwise than by judicial means followed by prompt and adequate compensation. A concessionaire likewise defeats his own purposes if he fails to recognize his status as a trustee charged with effecting the maximum ultimate usefulness of the nation's irreplaceable minerals.

53. The less developed nations are competing for the accumulated savings of the investors of the world in order to provide the means to search for and develop their resources; and they are also competing for the markets of the world, into which to move those resources if the search is successful.

54. In this dynamic age, the age of minerals as some have called it, no nation is a law nto itself. When we extract and consume minerals, we are reducing the planet's fixed and irreplaceable endowment, living on capital, not income. Therefore all of us, whether producer or consumer, whether living in a nation that exports capital and technical skills or a nation that receives these and puts them to use, have inseparable stakes in the wisdom of the mineral development laws of every part of the world.

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United States of America

METALLURGICAL, DOMESTIC AND INDUSTRIAL UTILIZATION OF LOW-RANK COALS

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

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METALLURGICAL, DOMESTIC, AND INDUSTRIAL UTILIZATION OF LOW-RANK COALS

by

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1. The proper utilization of coal resources is an important, and possibly essential, step in the advancement of less developed areas of the world. Coal is a widely distributed mineral, usually comprising a significant potential source of energy and chemicals where the reserves of coal are adequate and where it can be economically mined. The low-rank coals of the world are widely distributed; but their utilization, particularly in expanding economies of the less developed areas, has been restricted, because of their chemical and physical properties. Low-rank coals for the present purpose include brown coals, lignites, and subbituminous coals, corresponding to classes 10 through 15 of the International system for classifying brown coals and lignites. They are all characterized by high moisture content, a relatively low heating value, high oxygen content, inability to fuse to produce coke, and high susceptibility to spontaneous combustion during transportation or storage.

2. In less developed areas of the world, the major historical usage of low-rank coals has been as fuel for local consumption. Even this restricted use, however, has been difficult in many areas because these coals cannot be burned successfully and easily in equipment used with wood, charcoal, and other traditional fuels. The purpose of this paper is to present and discuss techniques applicable in these areas that would permit the extension of the use of such coals as technologic and industrial development progresses. Within the space limitations of this paper, it will not be possible to do more than suggest or mention many of the possible areas and techniques of utilization. It is my intent, however, to show that widespread application can be made of such fuels through the use of technologies and information now available.

3. Coal utilization may best be discussed under several general categories. I have chosen to emphasize the application of low-rank coals to iron ore reduction because of the widespread international importance of metallurgy and the projected expansion of the steel industry in the less developed areas of the world.

4. Since prehistoric times, metallurgical operations have used charcoal or anthracite as a source of heat and as a chemical reducing agent. These fuels, however, are too costly or do not possess the proper physical or chemical properties for use in modern, large-scale metallurgical operations. As the need for stronger, cheaper, and more uniform fuels developed for these applications, the metallurgical industry concentrated in those areas of the world having coking coals. Small local metallurgical industries persist to this day in countries not so fortunately endowed, but such installations are not adequate to serve the needs of an expanded industrial economy.

5. The most intriguing, useful, and desirable metallurgical application of coal in our present economy is in the production of pig iron. The blast furnace is used almost universally, in one way or another, to produce this material. Because of the requirements of the blast furnace, the fuel supplied to modern units is a strong, hard coke, containing low concentrations of water and volatile matter. Low-rank coals do not possess the property of directly fusing in the coke oven to form such a coke. If they are charged in their natural state as a coke substitute, the blast furnace cannot function because the coals, in addition to having a high volatile matter content, will crumble and clog the passage of the air blast. However, recent developments have demonstrated two processes by which pig iron can be produced with noncoking coals. The first of these is the modification, through suitable processing, of the low-rank coals to form a synthetic coke that can be charged as part of the burden in conventional or modified blast furnaces. The second approach is the utilization of metallurgical techniques not requiring the use of the blast furnace. It is not the purpose of this paper to discuss the relative merits of these two techniques, as the choice between them transcends technologic consideration.

6. The production of synthetic coke by modification of low-rank coals consists basically in changing the chemical structure of the coal to reduce its moisture, oxygen, and volatile matter contents, to increase its fixed carbon content and heating value, and to consolidate the modified coal into a strong, dense agglomerate. The FMC Corporation and the United States Steel Corporation, both of the United States, have recently developed and announced a process to accomplish these results. This process, generally known as the "FMC Process", consists of the following steps:

(a) Stage crushing of the coal to less than 1/8 inch (3.2 mm).

(b) Preprocessing of the crushed coal by controlled oxidation at a relatively low temperature in a fluidized bed in order to modify both chemical and physical nature of the coal.

(c) Carbonization of the modified coal in a fluidized bed to produce a low-temperature char (semicoke) and sufficient condensable tar for use in the subsequent briquetting operation.

(d) Production of a low-volatile char by recarbonization of the low-temperature char at high temperatures in a fluidized bed.

(e) Briquetting of the high-temperature char with the entire output of low-temperature tar in conventional, high-pressure, opposed-roll presses.

(f) Controlled oxidation at moderate temperatures in a shaft furnace to modify the chemical nature of the tar binder.

(g) Recarbonization of the modified briquets at high temperatures to produce a strong, low-volatile matter briquet suitable for blast furnace and other metallurgical applications.

A comparison of the physical properties of large size FMC Process briquets and similar properties of conventional foundry coke is given in table 1 (see annex). The FMC briquets may be made in any size, and it has been indicated that reactivity and other properties of the briquets can be controlled by selection of temperature, residence time, and other operating variables.

7.. Brown coal and lignite have effectively been converted in various parts of the world to materials suitable for use in low-shaft furnaces. Many of these low-rank coals are briquettable in high pressure equipment without the use of binders. This technique, where applicable, requires crushing and drying of the high-moisture lignite or brown coal to a preestablished optimum moisture content, briquetting in high pressure equipment, and carbonization of the briquets to high temperatures to produce a low volatile coke. The heating schedule for the carbonization is critical, but an excellent product can be obtained by this technique. For those lignites and brown coals not briquettable without a binder, briquets can be produced from either the dried or carbonized coal using pitch or other binders. Such briquets are usually carbonized to produce a low-volatile, hard coke. If high density fuels are not required, it is possible to pelletize coal with suitable binders and to carbonize the pellets by a carefully controlled heating schedule in a stream of hot natural gas or methane. This treatment sets the aggregate into a strong cokelike structure.

8. The other major approach to the utilization of low-rank fuels in the production of pig iron involves the use of techniques not requiring the blast furnace. There are a variety of such "direct reduction" processes that have either been tried or suggested, but most of them make use of an inclined rotary kiln into which a burden of ore, flux, and solid fuel is charged. As the burden moves through the kiln, some of the fuel burns in the air blast introduced at the discharge end to produce the heat required for the reactions; the remainder of the fuel then acts as a chemical reducing agent to produce metallic iron (or partially reduced iron oxides) from the oxide ores. There are many variations possible in this approach. For example, some processes produce a molten slag of vitreous material in which the iron particles are suspended. The slag issuing from the kiln is quenched and crushed, and the iron particles are collected by gravity separation or by magnetic means. In other processes, the kiln is operated under nonslagging conditions producing either finely divided metallic iron distributed throughout the nonfused product, partially reduced iron ore, or a mixture of the two.. It has been successfully demonstrated that char or semicoke made by the carbonization of low-rank coals is a satisfactory fuel for use in direct reduction kilns. These chars, generally produced in entrained or fluidized beds, are highly reactive, and if formed at the proper temperature, they do not produce any objectionable tars or liquids that could affect the operation of the necessary dust collecting apparatus used at the gas discharge end of the kiln. It has also been demonstrated that raw lignite can be used efficiently as the reducing agent in at least one of the direct reduction operations. It is likely that, through suitable modification of operating techniques, raw, dried or carbonized lignite, brown coals, and subbituminous coals can be used in a variety of the direct reduction processes.

9. The use of low-rank coals in the production of pig iron can be accomplished, then, through either the radical modification of the coal to produce a synthetic cokelike material that can be used in the blast furnace or the application of direct reduction kilns with either raw or modified noncoking coals as the fuel. The choice between these two approaches is an extremely complex one, depending upon quality and physical structure of the ore, as well as upon economic and other technological considerations.

10. Other metallurgical processes, such as scrap melting, slag reprocessing, and reduction of nonferrous metals, can utilize the coke substitutes prepared from the low-rank coals. These coke substitutes can also replace coke in other industries; for example, FMC Process briquets have been used in electric furnaces producing elemental phosphorous.

11. Sources of adequate fuel for domestic heating and cooking are becoming increasingly important problems in many of the less developed areas of the world. The fuels frequently used in these areas are wood , charcoal, and dried dung. The source of wood and charcoal has been the forests contiguous to centers of population, and a natural balance has been effected over the centuries between the use of the wood and the rate of growth of the forests. In recent years, however, such balances have been upset in many places by the rapidly increasing population. The forests are being depleted, the source of wood is receding from the population centers, and the cost of wood or charcoal is increasing rapidly. Raw low-rank coals can be used effectively for cooking and heating; however, it is necessary to have stoves and furnaces specifically adapted to the burning of high moisture solid fuels. Such equipment is not readily available in the less developed areas of the world. In addition, there are established techniques of cooking and heating based upon the traditional fuels available in these areas. Eventually, it might be possible to modify the habits of the inhabitants of these areas so that the coals can be burned directly in proper stoves and furnaces, but this will be a slow process. The better solution, and one more likely of immediate acceptance, is to modify the low-rank coals by processing so that the resulting products can be burned in braziers and other existing equipment in the traditional manner.

12. Let us examine the properties of the traditional fuels and compare them with the equivalent properties of the low-rank coals. Wood is an easily stored, easily ignited fuel requiring no special equipment for its handling or use. When it burns, however, it produces a smoky flame with an acrid odor. As a consequence of this smokiness, the practice has developed in many villages and towns of burning charcoal. Charcoal is also an easily ignited, handled, and stored fuel. It burns without odor or smoke and is well suited for use in populated areas and in kitchen stoves not equipped with flues or smoke stacks. Dried cow- or water-buffalo-dung is easily stored and ignited. While it burns with a distinctive odor, it does give a smokeless flame and is an extensively used fuel. All three of these fuels are easily handled and consist of relatively large size particles that can be burned in simple equipment with little difficulty in providing adequate draft. When the immediate use is complete, the remaining fuel can be extinguished with water, allowed to sun dry, and later reignited and used until it is completely consumed.

13. The low-rank coals, on the other hand, are characterized by high moisture content. Lump low-rank coal will slack and degrade to fine sizes or powder as the natural moisture in the coal evaporates if it is stored by simply piling or stacking. The resulting powder, or dust, is not suitable for burning in braziers.

If the coal lumps are charged while they are fresh, that is, with their full moisture content, they are very difficult, if not impossible, to ignite in such equipment. As the lumps become heated in the fire, they dry and disintegrate, producing powder which chokes the fuel bed and prevents combustion. It is almost impossible to quench and recover unburned lumps from a fuel bed prepared from low-rank coals.

14. The problem, then, is to convert the coal into materials having properties as similar as possible to the preferred fuels. The general approach is to briquet the coal. Some of the low-rank coals can be crushed, dried to an optimum moisture content of about 10 to 16 percent, and briquetted without binder in high-pressure extrusion presses. The resultant briquets are then carbonized, converting the coal into a smokeless, easily ignited, free burning char or semicoke briquet. The carbonized briquets are relatively porous and are reactive enough to be ignited by the same procedure used by the housewife for igniting charcoal.

15. If the coal cannot be briquetted without binder, an additive must be used to provide the cohesiveness necessary to form briquets. Such coals are carbonized to eliminate moisture and reduce the volatile matter content, and the char is briquetted with a suitable binder. Starch, molasses, kraft paper waste, portland cement, clay, and other binders have successfully been used for this purpose. Excellent binders are pitches and asphalts. These latter materials coke when heated and form an extremely strong matrix, giving coherence to the briquet in the fuel bed. However, they burn with a smoky flame, and it is generally preferable to recarbonize these briquets before use in open domestic appliances. The problem of odor occurring during the burning of carbonized coal briquets made from char and tar has become important in the United States because of the use of such briquets for outdoor cooking. One of the major producers of carbonized coal briquets in the United States has effectively eliminated such odor through proper cooling of the char and briquets, and by the addition of small quantities of additives and catalysts. These briquets are finding wide acceptance as a premium domestic fuel.

16. One of the largest and most important uses of coal in the less developed areas of the world will probably be in thermal power plants. It has been adequately demonstrated that any of the low-rank coals can be burned efficiently in modern equipment, and the use of coal is primarily determined on the basis of economics. Small power plants can burn the coal on spreader or traveling-grate stokers, or the coal may even be hand-fired. Larger plants will probably use pulverized fuel burners. High-moisture coal must either be partially dried or very finely ground before it enters the pulverized fuel burners. The modern approach is to partially dry the coal, either by using hot-gas-swept pulverizing mills or by predrying the coal before pulverizing. Large power generating plants in the United States using lignite with 35- to 45-percent moisture as the fuel are operating successfully with each of these drying schemes. Pulverized fuel burning is also successfully employed on brown coal and peat in other parts of the world. Processes and techniques for drying the low-rank coals to any predetermined moisture content are well developed and are available in any capacity.

17. The coal-burning gas turbine offers another route by which the low-rank coals can be used for power generation. Extensive pilot plant research is being conducted in several laboratories on the development of this technique. The coal-burning gas turbine will be able to generate power with the consumption of far less water than is required for the conventional thermal-electric plant, a feature of tremendous importance in arid areas. It should be kept in

mind, however, that the coal-burning gas turbine is still in the process of development. The main problem yet to be solved is the development of a unit that will perform for long periods of time between outages for other than routine maintenance. The research being conducted in this field should prove productive, and it is believed that an extremely reliable unit will be developed. When this is an accomplished fact, it will be possible to make a rational economic analysis of the application of the coal-burning turbine for a particular installation. It should be pointed out that factors other than the savings in water are of significance in the selection of power generating equipment.

18. New developments in the transportation of energy may influence the location of coal-burning thermal-electric plants and the economics of their operation. While these developments will probably be discussed in detail by the specialists on power generation, it is felt that attention should be called to suggested techniques that could extend the economical utilization of coal. These include pipeline transportation of coal-in-water or coal-in-oil slurries, improved and more efficient equipment and procedures for rail transportation of coal, and extra high voltage (over 400 KV ac or about 375 KV dc) transmission of power. The cost of delivering the coal to the power plant and of delivering power to the distribution center are significant factors in determining the economic position of coal-burning thermal-electric plants.

19. In many parts of the world, coal historically was the main source of railroad fuel. In recent years it has been supplanted to a large extent by diesel fuel. This change in fuel supply has been dictated almost entirely by economic reasons. In those countries having adequate reserves of cheap, low-rank fuels, and where coal can be produced at a lower energy cost than diesel fuel, a definite area of application for railroad use exists. Because of the properties of low-rank coals, it is usually unsatisfactory to charge raw high-moisture coal to the firebox of a locomotive. With the high temperature and high draft conditions found in the firebox, the high-moisture coals break down into small particles and a large percentage of the fuel is lost up the stack. This obviously presents serious problems of economy and nuisance. It has been found, however, that briquets made from such coal are very satisfactory for railroad use. The type of briquet used is determined by the properties of the coal. For example, some high-moisture coals can be partially dried to 10- to 16-percent moisture content and briquetted without binder. Such briquets are excellent fuel. For this application it is not necessary to produce a smokeless briquet as was the case for domestic cooking, because the draft conditions in the firebox will burn most of the volatile matter. If a binder is required, satisfactory briquets for railroad use can be made by briquetting the dried or carbonized coal with a pitch or asphaltic binder. When such briquets are charged into the firebox, the hydrocarbon binder decomposes and forms a coke matrix, binding the coal fines into a lump-like structure.

20. Low-rank coals can be used in a variety of special industrial applications. Possibly the most significant of these to the less developed areas is the use of such fuels for cement burning. In order to efficiently burn cement clinker, it is necessary to develop a temperature of at least 3,000° F (1,650° C) in the kiln. Because of the heat required to evaporate water from high-moisture low-rank coals, it is not possible to develop the necessary temperature with these coals unless costly and complicated air preheating devices are used. If these coals, however, are dried before being pulverized and charged to the burner in the kiln, a flame temperature high enough to burn clinker can be obtained. This technique permits the substitution of low-rank coal for higher-rank coal or other

fuels for this very important application. The drying of coal in the large quantities required for cement burning can be accomplished economically, in existing equipment. The upgrading of low-rank fuels for cement burning and other industrial applications requiring high temperature could well prove to be one of the most significant uses of the high-moisture coals in the less developed areas. Extraction of montan wax and the production of low-ash material suitable for carbon electrode manufacture are among the possible minor industrial applications of selected low-rank coals having the right chemical properties.

21. It is well known that any rank of coal can serve as the basis for the production of a variety of organic chemicals. Coal supplies the necessary building blocks of carbon and hydrogen, and these can be formed into practically any synthetic organic compound. Carbonization, hydrogenation, gasification, and catalytic treatment are some of the major techniques used. The possibilities for such treatment are only mentioned within the context of this paper. Economic analyses have demonstrated that the production of chemicals by these techniques is competitive only when conducted on a very large scale. Such analyses have shown conclusively that there must be almost complete utilization of the fuel and of the byproducts in order to be economically attractive. Both of these considerations require that a well developed industrial complex be established in order to use the quantity and variety of products that must be produced if such chemical processing is to be economical. By definition, the less developed areas do not yet have such complexes. I believe that it is premature to consider specific chemicals that can be made from the low-rank coals, but some of the major types of products that can be made from these fuels are solvents, protective coatings for pipe, rubber plasticizers, phenolic compounds for plastic manufacture, dye stuffs, fertilizers, and pharmaceuticals.

22. There are, however, two general areas of chemical utilization of the coal that might be considered; namely, synthetic liquid fuel and fertilizer production. Synthetic liquid fuels can be produced by complete hydrogenation of coal at high pressure and temperature and with suitable catalysts, or by the catalytic conversion of "synthesis gas", a mixture of carbon monoxide and hydrogen, obtained from the controlled gasification of the coal. The general use of these techniques for producing liquid fuels is well known, although specific application to any given coal would have to be studied through laboratory investigations. Each of these processing schemes results in relatively complete conversion of the coal. Low-rank coal may be carbonized in an entrained or fluidized carbonizer to produce tar for hydrogenation to liquid fuels. The difficulty, however, with this process is that about 65 percent of the potential heat in the coal remains in the char residue and uses must be found for this fuel. Large quantities of char will be produced and must be consumed if an economically sized plant is constructed. The major application for the char in large quantity would be for power generation, since char is an excellent fuel and can be efficiently utilized in properly designed power plants. It should be kept in mind, that if this latter application is considered, a large power generating industry is required to maintain a balance in the utilization of the two major products.

23. Nitrogen-containing fertilizers are of extreme importance to the less developed areas of the world. Atmospheric nitrogen is fixed by combining it with hydrogen at elevated temperatures and pressures. Low-rank coals provide a source of the hydrogen through either carbonization or gasification.

Carbonization requires that uses be found for the char and tar produced concurrently with the hydrogen and again an integrated, balanced, industrial complex is necessary. Gasification, on the other hand, results in reasonably complete conversion of the coal to hydrogen and carbon monoxide, and these two products can be readily separated. The carbon monoxide can be utilized as a low quality gaseous fuel even if no specific chemical application is available. Fluidized techniques are attractive for gasification, but conventional vertical shaft retorts using the briquetted fuel will probably prove more economical for carbonization. Fertilizer production must be conducted on a large scale to be economical, and large quantities of power are required. Such an industry should, therefore, be integrated with an adequate power generating installation.

24. Naturally oxidized lignites, such as leonardite, can be used as soil conditioners. They contain large percentages of naturally produced humates that are beneficial to the soil because of their ability to hold water and loosen the soil. Oxidized lignite generally occurs as outcrops or in beds under shallow, porous cover. The natural process of oxidation occurring over long periods of time can be approximated by chemical oxidation. Humates can then be extracted from the converted coal, or the entire mass of oxidized materials can be used as a soil conditioner. Oxidized coals, because of the water holding power of the humates, are being used as additives to mud used in well drilling.

25. Any of the low-rank coals can be used for general industrial heating. They can be handfired or charged with a variety of mechanical stokers such as underfeed, traveling grate, or spreader. For such purposes it is not necessary to preprocess the coal, although care must be taken in selecting equipment designed to handle the type of ash found in the particular coal. For example, if the ash in a given coal has a high fusion temperature, the coal cannot be used in equipment requiring clinkering of the ash, and accordingly, a low-fusion ash coal must be used in equipment providing for clinker removal. Most handfired units require lump material, but the fines can be briquetted as described before to make lumplike material suitable for handfiring.

26. Specialty carbons can be made from a wide variety of the low-rank coals, particularly those with low ash contents. Some uses, such as electrodes for electrochemical applications, would not be of immediate interest in the less developed areas. The use of activated carbon produced from low-rank coals for water purification could be profitable. It is possible to convert lignite and other high-moisture coals to excellent activated carbons by carbonization in simple devices. For example, such carbons have been made in large quantity in externally heated rotary kilns, with no byproduct recovery.

27. Storage is a very important factor in the utilization of low-rank (high-moisture) coals. These coals become extremely reactive as they lose moisture. As the moisture evaporates from the capillaries in the coal, new internal surfaces are produced. In addition, the coal slacks or crumbles, also creating new surfaces. These new surfaces are extremely reactive, and any appreciable lot of low-rank coals merely heaped on the ground is susceptible to spontaneous combustion. This tendency towards firing has been a deterrent to the large scale use of low-rank coals in many parts of the world. Storage is important because it is usually not possible to integrate mining and transportation of coal with utilization in order to prevent the necessity for storage. For example, climatic conditions may make it necessary for mining to be practiced only during a portion of the year. It may be too cold or too wet to operate the mines and to transport the coal during some seasons. If the coal cannot be properly stored, usually at point of use, it becomes necessary to restrict

coal use to those industries operated on a seasonal basis. Seasonal operation would not be attractive to the power industry, where production is required throughout the year.

28. As mentioned earlier, the difficulty in storing low-rank coals arises from the drying of the coal and its subsequent oxidation and heating. This heat escapes slowly and the temperature rises, increasing both the rate of drying and the rate of oxidation. This spiral continues until the coal pile ignites. The proper technique of storage, therefore, is one which will prevent these effects. The best approach is to build the pile in layers. The coal is spread in a layer to reduce size segregation and is packed to a high bulk density before the next layer is formed. By increasing the bulk density of the coal in the pile, circulation of air through the pile is minimized. This technique has proven more effective than either ventilating the piles or covering them with thin layers of sealing materials. The packing technique has proven effective on large storage piles, each containing as much as 1,000,000 tons of lignite. Another deterrent to the stocking of high-moisture coals is their tendency to freeze in the cars when they are shipped by rail in extremely cold weather. When this occurs, it is necessary to break up the coal or thaw it before the car can be unloaded. It has recently been demonstrated that freezing can be prevented by mixing a relatively small proportion of thermally dried coal with raw coal before loading.

29. The logical assignment of coals for specific uses requires at least some testing or research. It is to this phase of coal utilization that I would like to direct a few remarks. I have observed that in some areas where there is little or no experience in coal utilization, the need for pretesting the coal to establish its properties and amenability to a specific use has not been recognized. It cannot be emphasized too strongly that even though we speak of coals in terms of large classes, each coal has certain individual characteristics that cannot be predicted. It is necessary in our present state of knowledge to treat such coals as individuals and to determine their specific capabilities. It is certainly possible for an experienced coal technician to block out the general areas of application from only a cursory examination, perhaps by only a visual examination, but selection of the specific equipment and optimum operating conditions requires testing and analysis of the coal.

30. If it is accepted that some competent examination of the coal should be made before utilization processes are finalized, the question arises as to how and where such studies should be made. Laboratory and research facilities should be established in each coal producing country, but it is necessary that selected local personnel be trained in a country having an established coal industry and adequate research facilities. This training can then be utilized in the orderly establishment of the local research facilities. Parallel to this training of laboratory personnel, specific initial coal utilization problems of the less developed area should be studied in existing laboratories in the more developed areas. By obtaining research data and design suggestions from established industrial countries, coal production and utilization can be initiated in an efficient and reasonable manner. The existence of even a nucleus of a coal industry then provides the impetus for the development of the local laboratory and research facilities. It is very difficult to maintain continued interest and support in a laboratory being established in a country without the support of an operating industry in the same field.

31. A realistic approach to coal research must be maintained in development of the new facilities. The distinction must be recognized between fundamental and applied research, and the proper distribution of effort made in the research organization between these two lines. I believe that the most effective approach to the establishment of a coal research organization is to emphasize studies on applied technology. If the local laboratory can demonstrate the application of an existing technique or the development of a new technique that will result in production and utilization of a local coal, continuing financial and political support for this laboratory will be easier to obtain; the laboratory can then expand its fundamental studies.

ANNEX I

TABLE 1. - Physical and chemical properties of FMC Process and foundry cokes [1]

	Coke from FMC Process	Foundry coke
Shape	Uniform pillow blocks	Random
Size, inches	As desired, up to 3-1/2 x 4	Random, up to 4 x 8
Moisture, percent	1-2	1-2
Drop shatter index	92 +	92 +
Tumbler index	92 +	92 +
Crushing resistance, psi	3,000-6,000 [2]	2,000-4,000 [3]
Apparent specific gravity	1.0-1.05	0.95
True specific gravity	1.95	1.95
Bulk density, lb ft^{-3}	38-42	28-32
Proximate analysis, moisture-free basis, percent:	[4]	[4]
Volatile matter	2-3	1-2
Fixed carbon	92-95	88-93
Ash	3-6	5-10
Sulfur	0.5-0.8	0.5-1.0

[1] Data supplied by the FMC Corporation, New York, N.Y., U.S.A.

[2] Based on cylinders of one-square-inch cross sectional area.

[3] Based on 1/2-inch cubes.

[4] Analyses shown are typical. Actual values depend upon ash and sulfur content of the coal used.

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THE ESTIMATION OF RUN-OFF IN A MOUNTAINOUS REGION

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

THE ESTIMATION OF RUN-OFF IN A MOUNTAINOUS REGION

1. The aim of this paper is to describe the methods used to estimate run-off for the preliminary studies and detailed design of the Snowy Mountains Scheme in south-eastern Australia.

2. The location of the Snowy Mountains is shown on Figure I and a cross section through them on Figure II. The climate of the region is not severe compared with the alpine regions of the other continents. The precipitation varies widely from an estimated maximum of the order of 150 inches per annum to a minimum of 20 inches. In winter and spring there is a predominance of westerly weather with depressions and frontal disturbances moving from west to east. Accordingly the western slopes receive heavy falls of rain and snow which are increased by orographic lifting, while there is a rain shadow to the east. Snow covers the ground for about six months of the year. The summer and autumn are drier, although with the weakening of the westerly circulation, there are occasional intrusions of tropical air and moderate thunderstorm activity; in these months the eastern slopes are favoured. The effects just described are illustrated on Figure II.

3. The essence of the Scheme is the diversion of the Snowy River into the Murray and Murrumbidgee Rivers. By taking advantage of the east-west difference in levels, large quantities of power can be generated as the water is diverted inland. Altogether there will be 9 major dams, 10 power stations, 100 miles of tunnels and 80 miles of aqueducts. The estimated cost of the Scheme, commenced in 1949 and now half completed, is £(A)400,000,000. Annual expenditure has averaged £(A) 15,000,000.

VARIABILITY OF RUN-OFF

4. The variability of run-off in an area greatly influences the planning of its hydrologic network and the estimation of its run-off; in mountainous areas its importance is accentuated because it is usually high. The run-off distribution in the Snowy Mountains illustrates the variation which may occur in a relatively compact and apparently homogeneous area. For example, the measured average annual run-off of a small catchment of 1.8 square miles with an average elevation of 6,300 feet near Mt. Kosciusko was 13.0 feet during the period, 1953-1960. During the same period the run-off only 16 miles to the east was as little as 0.2 feet. Isopleths of estimated average run-off are superimposed on Figure I together with an inset showing the monthly distribution of run-off from the area as a whole. The contribution of the different calendar months to the

annual total may also vary greatly. In order to illustrate this, the monthly run-offs of a number of small catchments with mean elevations at approximately 1,000 feet intervals are shown on Figure IV.

5. The other feature of the variability of run-off is its temporal variability.[2,3] Long term streamflow records of the region should be examined but if these are not available, as is usually the case, precipitation records and other data should be studied. Kraus[4] found that the average annual precipitation of south-eastern Australia during the last 50 years, the period for which streamflow records are available, was about 10% less than that of the overlapping 100 year period. Even a variation in the seasonal distribution of precipitation without any significant trend in the annual average can materially alter run-off, since the losses are very much dependent upon temperature.

PRELIMINARY RUN-OFF ESTIMATES

6. Although long streamflow records provide the only really satisfactory method of determining the run-off from an area, often there are none, or only a few of relatively short duration. In the former case the run-off must be estimated from precipitation by subtracting evapo-transpiration losses, while in the latter the records that are available can be used to derive relationships between precipitation and run-off which can be applied to ungauged areas or used to extend short records. A number of procedures for carrying out this type of investigation have been outlined by Linsley[5] who provides a useful bibliography. Langbein[6] and Penman,[7] among others, also give examples. Elsewhere Langbein[8] has demonstrated how, under certain conditions, long records of precipitation and run-off may be inferred from short records of lake or groundwater levels.

7. The run-off distribution of the Snowy Mountains was first estimated by a committee appointed by the Commonwealth Government in 1947 to investigate the power and irrigation potential of the region. This committee[9] produced a map showing isopleths of average annual run-off based on a relation between recorded streamflow and elevation characteristics and the distance east of the Great Dividing Range. This map was the foundation of the preliminary investigations which determined the general layout and feasibility of the Scheme. When the Snowy Mountains Authority was established in 1949, further detailed

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[2]McDonald, C.C. and Langbein, W.B., Trends in run-off in the Pacific Northwest, Trans. Amer. Geophys. Union, 29, 387-397 (1948).
[3]Williams, G.R., Cyclical variations in world wide hydrologic data, Proc. Amer. Soc. Civil Engrs., 87 No. HY 6, 71-88 (1961).
[4]Kraus, E.B., Secular changes in the rainfall regime of S.E. Australia, Quart. J. Royal Meteor. Soc. 80, 591-601 (1954).
[5]Linsley, R.K., Techniques for surveying surface-water resources, World Meteor. Organ. Tech. Note No. 26, Geneva (1958).
[6]Labgbein, W.B., Hydrologic data networks and methods of extrapolating or extending available hydrologic data, U.N. Flood Control Ser. No.15, Bangkok (1960).
[7]Penman, H.L., The water balance of the Stour catchment, J. Inst. Water Eng. 4, 457-469 (1950).
[8]Langbein, W.B., Water levels as indicators of long-term precipitation or run-off, Int. Ass. Sci. Hydrol. Gen. Assem. Helsinki; Comm. Surface Waters, 517-526 (1960).
[9]Commonwealth of Australia, Diversion and utilization of the water of the Snowy River, Final report of the Commonwealth and States Snowy River Committee (1950).

studies were necessary and this resulted in an expansion of the stream gauging network.

STREAM GAUGING NETWORK

8. The desirability of designing a stream gauging network is now generally recognized; Kohler[10] gives useful advice and references on this question. The growth of the Authority's network is shown on Figure III. The density of the network was governed by the variability of the run-off and the intensity of the proposed development. Ultimately there will be from 60 to 70 diversion points, excluding minor intakes of aqueducts. The network was designed to cover all possible methods of development so that a number of stations were established at locations well removed from the final layout.

9. The almost concurrent investigation and design of the Scheme called for the production of data from the gauging stations as soon as possible. The manner in which this was achieved is described elsewhere.[11,12] After completion of the investigation of a project, the gauging stations associated with it have been discontinued except those required for operational purposes. Thus, in practice, the gauging station network has been operated along very similar lines to Langbein's[13] concept of base and satellite stations. Typical short term records have been from five to eight years.

FINAL ESTIMATES OF RUN-OFF

10. The records from the network just described have provided data for the final investigations which determined exact dimensions. They have all been extended back to 1905 because the records of the basic long term stations are available from that year, and because extension to 1848 (by correlation with rainfall) of the records of the two major rivers draining the area showed that the period from 1905 could be regarded as conservative. The time unit adopted has been the calendar month since this was the most suitable unit for the problems of storage design and operation which have been encountered. For the small diversions daily flows have been required but these estimates are not discussed in this paper.

11. Precipitation data have not been used directly in the extension, firstly, because the streamflow data have been adequate, and secondly, because with a high proportion of the winter precipitation occurring as snow which does not appear as run-off till a few months later, the precipitation of a given month is not related to its run-off. An associated factor is the low accuracy of precipitation measurements at exposed mountain sites where wind effects cause a marked reduction in the catch of snow and even rain.[14]

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[10] Kohler, M.A., Design of hydrological networks, World Meteor. Org. Tech. Note No. 25, Geneva (1958).
[11] Pender, E.B., Walsh, D.T. and Anderson, D., Hydrology in the Snowy Mountains area, J. Inst. Engrs. Aust. 28, 51-66 (1956).
[12] Leech, T.D.J., The training and use of sub-professional staff, J. Inst. Engrs. Aust. 31, 247-259 (1959).
[13] Langbein, W.B., How long should gauging stations be operated? Proc. 22nd Ann. Meet. Western Snow Conf. 19-26, (1954).
[14] Weiss, L.L., and Wilson, W.T., Precipitation gauge shields, Int. Assoc. Sci. Hydrol., Gen. Assem. Toronto, I, 462-484 (1958).

CORRELATION TECHNIQUES

12. The techniques used have been described by Brown.[15] For convenience, they were grouped into five main classes, each summarized below.

13. Simple correlation: This term denotes the case in which a single curve is used to define the relationship between two run-off variables. The curve may be fitted by inspection, by least squares analysis or by some graphical technique such as that put forward by Langbein and Hardison.[16] Logarithmic transformation has been found useful. The main weakness of the method is that no attempt is made to account for the natural variation in the relationship.

14. Parametric correlation: This denotes a method in which the data are first grouped according to the value of a physical parameter and a separate relationship is then defined for each group. The parameters applied have included the relative distribution of precipitation over the catchments, antecedent conditions, the season of the year, and temperature. This method corrects a number of the weaknesses of the simple correlation, particularly its failure to reproduce individual months accurately and its susceptibility to error when the period on which the correlation is based is not hydrologically representative of that to which it is to be applied. It is important, however, that there are sound physical reasons behind the choice of parameters and that there is an adequate sample size in each of the sub-groups. When rainfall parameters are used corrections to the monthly totals may be necessary.[15]

15. Multiple correlation: This denotes correlations in which the dependent variable is related to a number of independent variables by multiple regression analysis. Partial correlation analysis has been used extensively in the selection of variables and testing of their significance. The whole approach is very flexible since it is possible to fit either linear or curvilinear relationships, transform the data, or stratify it into groups. Its main advantages are that the analysis can be carried out in a completely objective fashion using recognized statistical techniques and that the computations are easily handled by electronic computers. An example of the method is given by Sharp and others.[17] The discussion of this paper by Riggs[18] is valuable in that it stresses the need for significance tests on the variables selected and gives some useful comment on the principles of the procedure.

16. Seasonal correlation: This is a particular case of a parametric correlation in which the data are stratified according to the calendar month or season of the year and then each group is treated separately by one or other of the techniques already outlined. It is important that the seasonal effect is real and that tests are made to see if the relationships derived from the different groups are significantly different from each other. An investigation to extend the record of the Swampy Plain River is given as an example. In this case, the

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[15] Brown, J.A.H., Streamflow correlation in the Snowy Mountains Area, J. Inst. Engrs. Aust. 33, 85-95 (1961).
[16] Langbein, W.B., and Hardison, C.H., Extending streamflow data, Proc. Amer. Soc. Civil Engrs. 81, Paper No. 826 (1955).
[17] Sharp, A.L., et al, Application of the multiple regression approach in evaluating parameters affecting water yields of river basins, J. Geophys. Res. 65, 1273-1286 (1960).
[18] Riggs, H.C., Discussion on "Application of the multiple regression approach etc." by Sharp, A.L. et al, J. Geophys. Res. 65, 3509-3511 (1960).

run-off of four surrounding catchments were tested as independent variables in a multiple regression analysis and relationships computed for each month separately. The variation of the gross correlation coefficients and standard errors is shown on Figure V. It is interesting to note that the most highly related variable changes three times during the year.

17. There are some useful methods which do not fall readily into the previous categories, for example, the method of deviations and the coaxial method described by Linsley, Kohler and Paulhus [19]

COMPARISON OF METHODS

18. In order to illustrate the practical effect of the different methods of extension, an example used by Brown[15] is given. Four methods were applied to a common five year period of record of the Snowy River at Island Bend and the Snowy River at Jindabyne. The methods were simple correlation with a line fitted by least squares, simple correlation (logarithmic) with a line fitted by the technique of Langbein and Hardison,[16] seasonal correlation, and a parametric correlation. The derived relationships were applied to extend the record at Island Bend by 43 years. The monthly values obtained were then used to prepare residual mass curves to determine the differences in the storages which would have to be provided to give varying degrees of regulation if the different sets of data were used. From Figure VI, it can be seen that although the average annual values are very similar, there is a significant difference in the sizes of the storages.

19. Even if a method does accurately estimate values over a short period, large errors can still arise in estimates of average annual run-off unless the period on which the relationship is derived is hydrologically representative of that to which it is to be applied. Periods of two years or even longer can easily be characterized by a dominant weather influence which departs strongly from the normal and gives a distribution of streamflow not typical of average conditions over a long period of time. As an example, the monthly run-off of the Crackenback River was related to that of a nearby catchment, the Swampy Plain River. The common period of record of 12 years was divided into three groups of four years and lines fitted separately to each as shown on Figure VII. In spite of the large scatter, the period, 1949-1952, would predict significantly higher average run-off than the other periods. The effect of these wide differences could only be avoided by the introduction of further variables or by the use of some form of parametric correlation.

CONCLUSIONS

22. From the experience which has been acquired a summary is made below of some matters which are considered to be of importance:
(a) The gauging station network should be planned with the concept of base and satellite stations in mind.
(b) A number of small index catchments at different elevations and giving good geographical coverage can provide very useful data.
(c) When estimating run-off, either average annual or monthly, it is desirable to consider the whole area and not small portions in isolation.
(d) In any extension of records, it is most important that the

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[19] Linsley, R.K., Kohler, M.A. and Paulhus, J.L.H., Applied Hydrology, McGraw - Hill Book Co. Inc., New York, 645-655 (1949).

underlying physical basis of any relationship is sound and that it is not applied to a period for which it is not representative.

(e) Tests should be applied to evaluate the significance of the variables selected in any streamflow correlation.

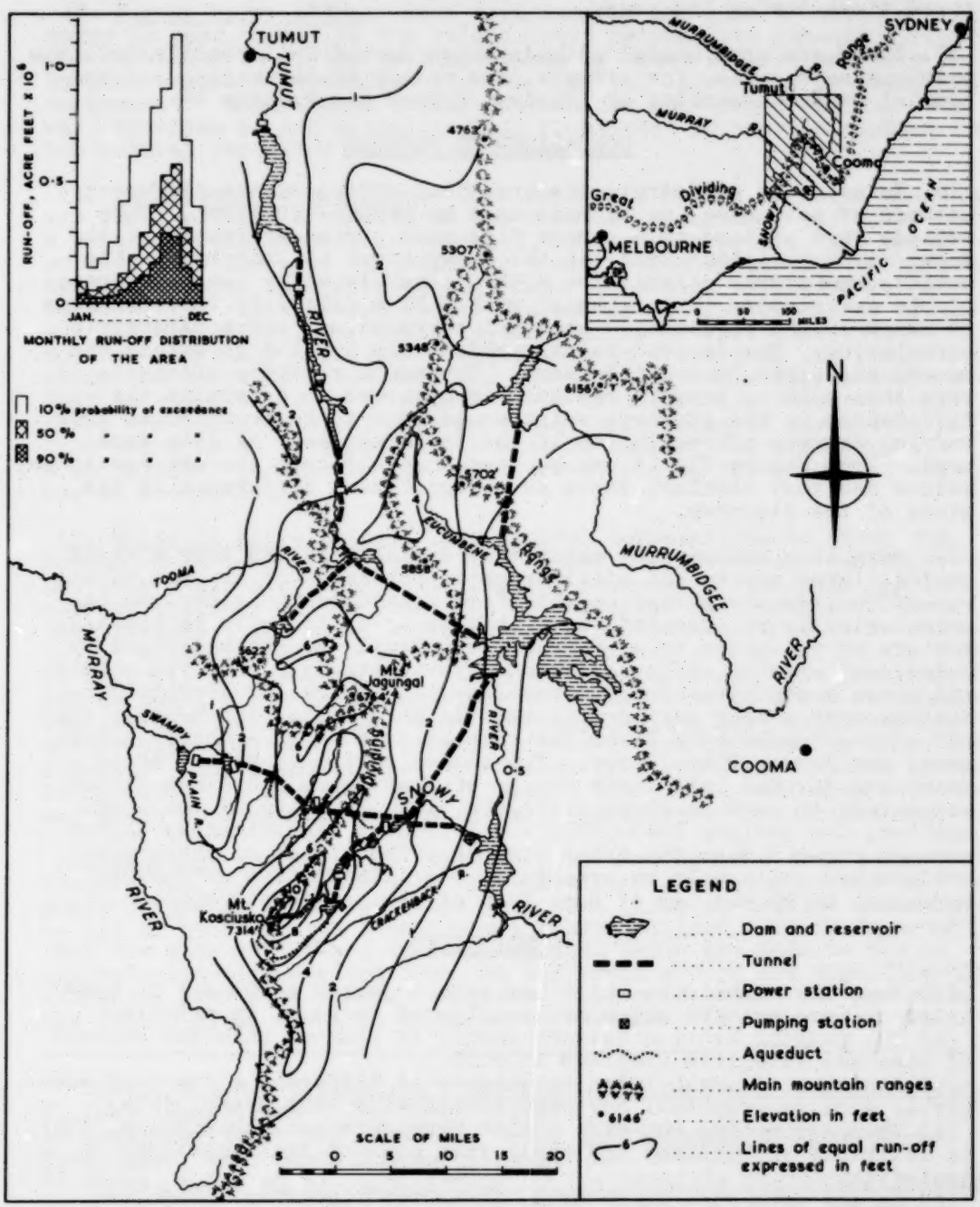


Fig. I. - Location map with details of Snowy Mountains Scheme and lines of equal run-off.

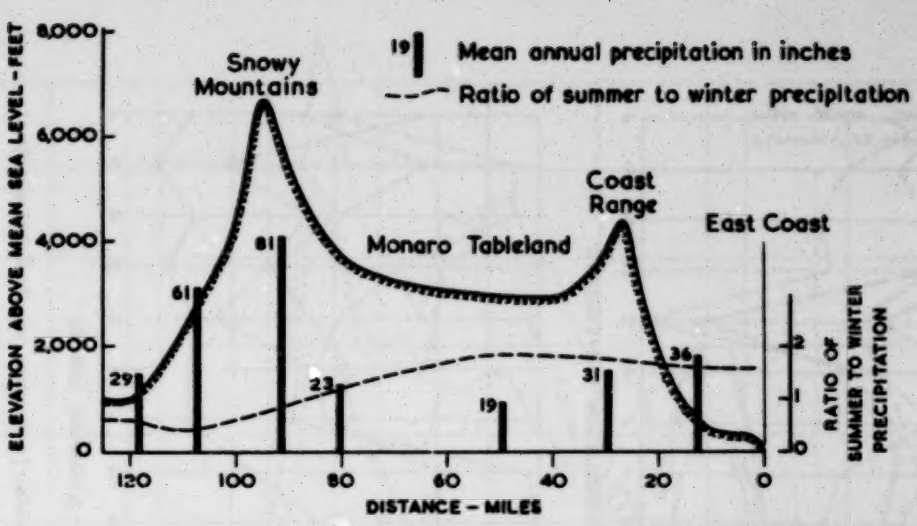


Fig. II - Generalized East-West cross section at latitude S 36° 09' (through Mt. Jagungal).

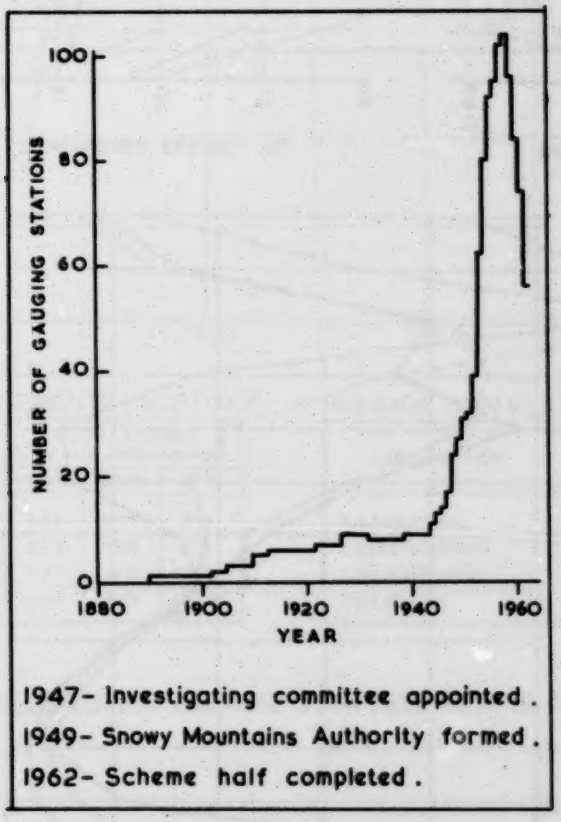


Fig. III - Variation in number of gauging stations

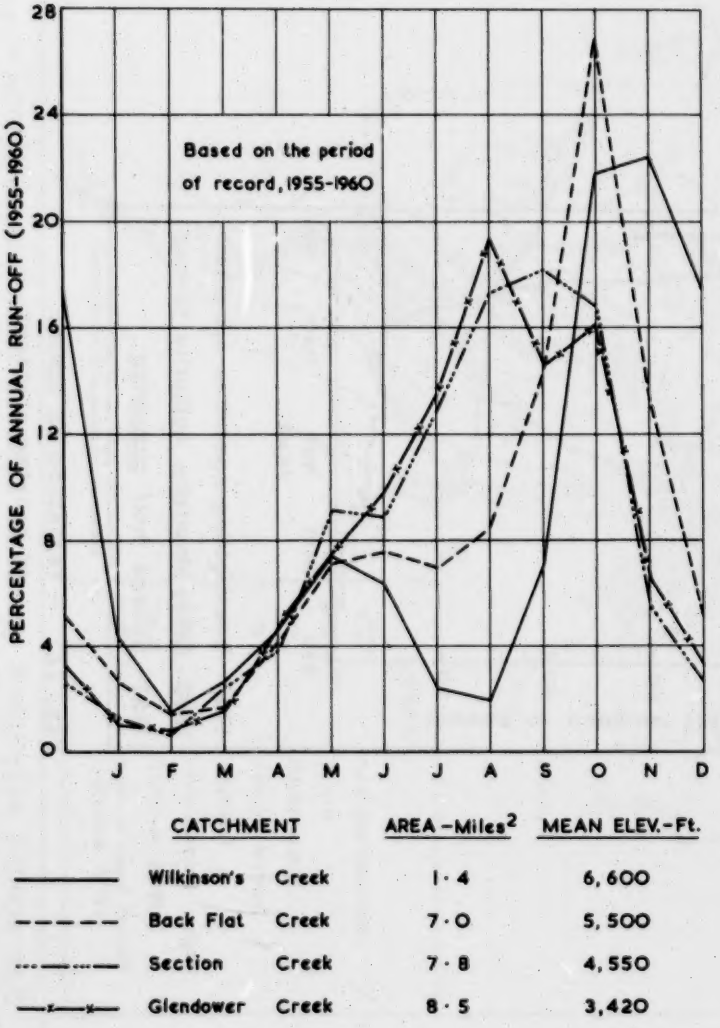


Fig. IV - Variation of run-off with elevation

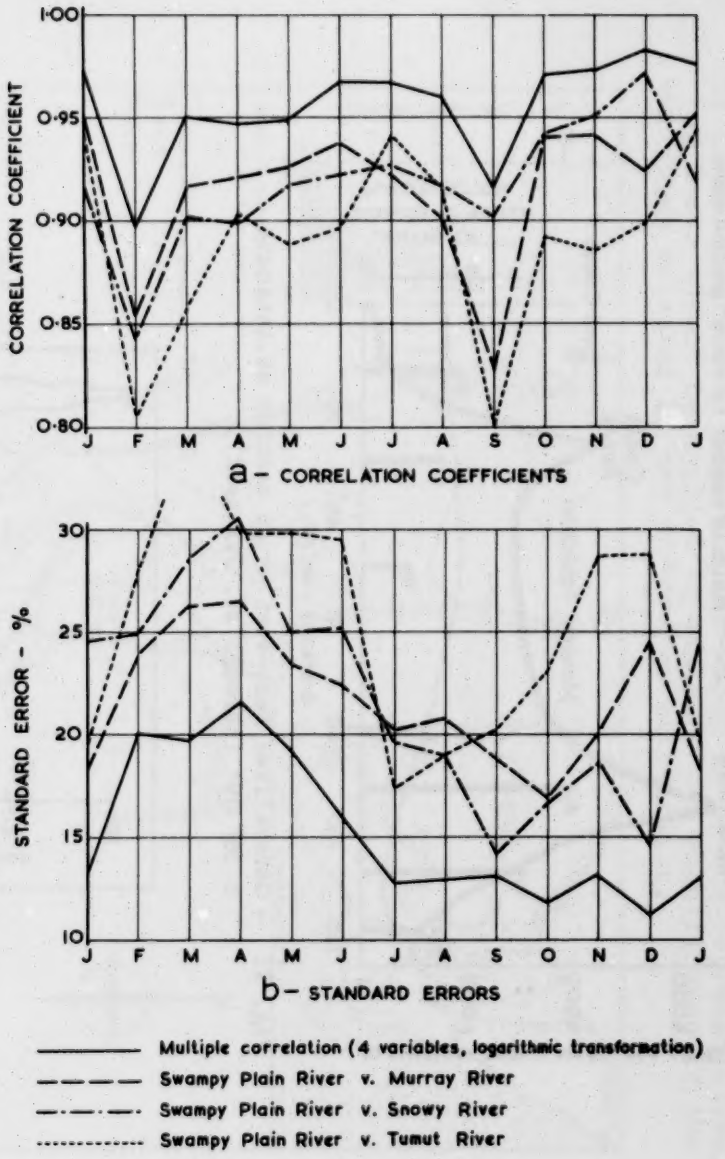
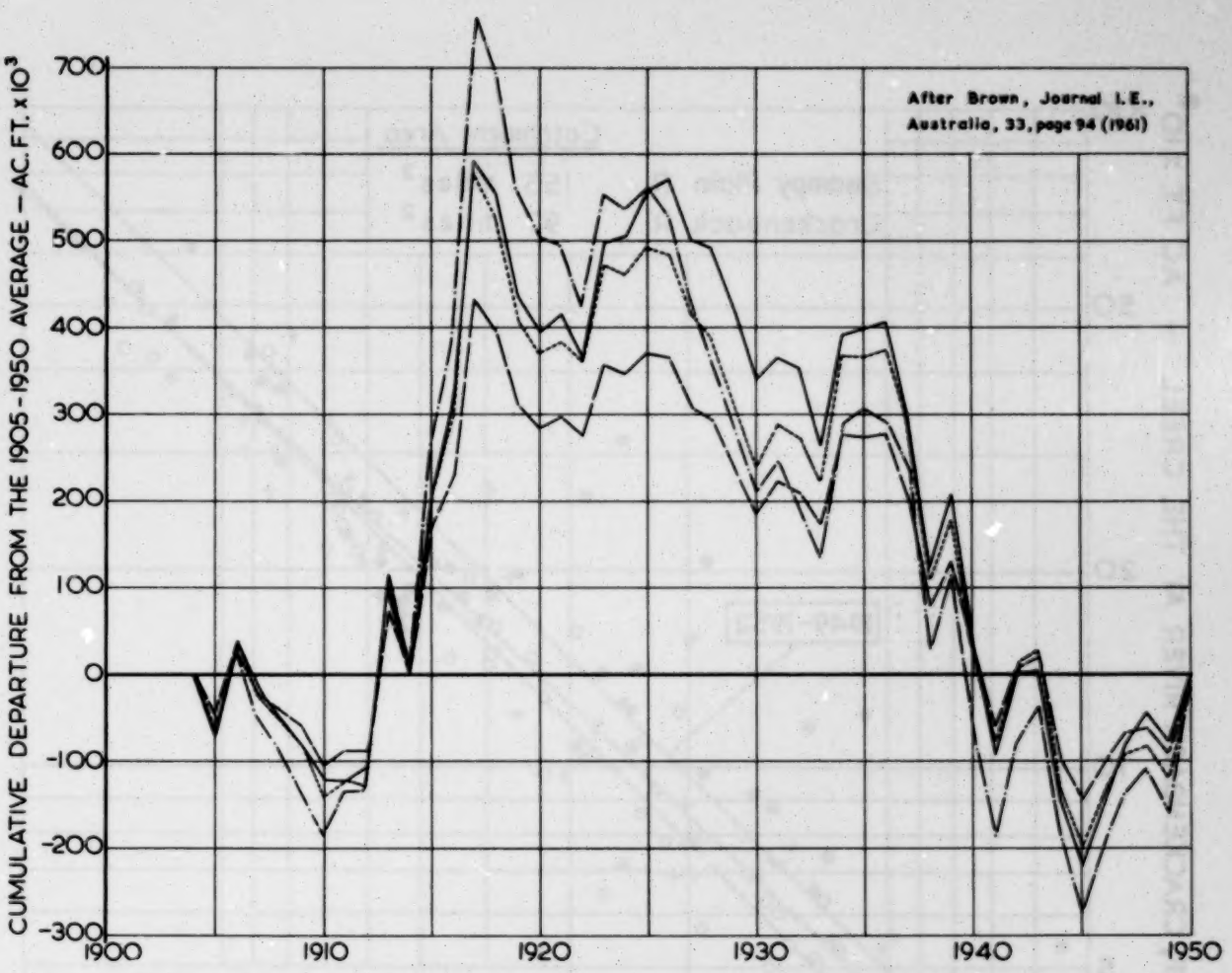


Fig. V - Example of seasonal correlation using multiple regression analysis



STORAGE REQUIREMENTS – AC. FT. x 10^3

CORRELATION	REGULATION – % OF 1905-1950 AVERAGE		
	100 %	90 %	85 %
PARAMETRIC	804	355	271
LEAST SQUARES	578	186	112
LOGARITHMIC	779	310	227
SEASONAL	1027	290	147

AVERAGE ANNUAL DISCHARGE — (1905-1950)

CORRELATION	DISCHARGE (AC. FT. x 10^3)	LEGEND
PARAMETRIC	303·1	———
LEAST SQUARES	296·3	———
LOGARITHMIC	298·2	- - - - -
SEASONAL	311·4	—·—·—

Fig. VI – Residual mass curves computed from data from different correlations

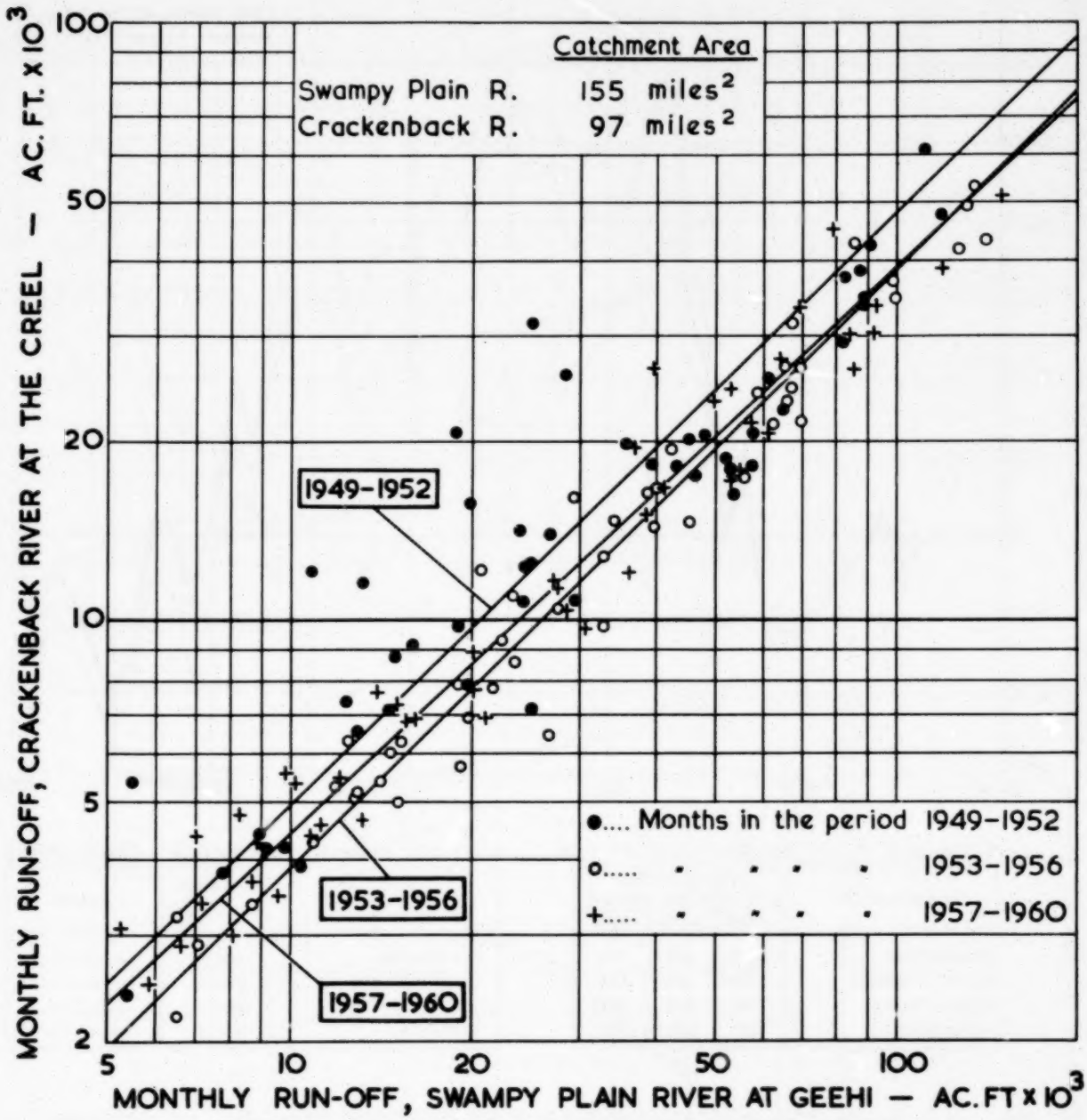


Fig. VII - Variation in run-off relationship curves fitted to successive four year periods

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UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A.5.2.2

Australia

MINING RESEARCH AND INDUSTRIAL ENGINEERING AT BROKEN HILL, AUSTRALIA, AND SELECTIVE OPEN CUT MINING AT MARY KATHLEEN, AUSTRALIA

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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MINING RESEARCH AND INDUSTRIAL ENGINEERING AT BROKEN HILL, AUSTRALIA AND SELECTIVE OPEN CUT MINING AT MARY KATHLEEN, AUSTRALIA

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MINING RESEARCH AND INDUSTRIAL ENGINEERING AT BROKEN HILL

1. Two associated companies, Zinc Corporation Limited and Broken Hill Consolidated Limited, operate adjoining mines at Broken Hill, New South Wales, producing annually about 700,000 and 600,000 tons respectively. The companies share a common management and services and mining research is not a strictly separate function. One senior official controls mine production, whilst a second controls Underground Services, Mine Planning, Surveying, Geology and Diamond Drilling. Co-ordination between these two groups is achieved at top management level. It is within the Underground Services and Mine Planning functions that mining research is conducted.

2. Mine planning is the process of designing layouts and stoping methods with the object of minimizing the cost of extraction and maximizing ore recovery. In so far as planning represents the application of new thinking, mine planning can be considered to include mining research. Design of mining layouts includes the consideration of such factors as methods of ground support and materials to be used, chute spacing and size related to chute wear and the method to be used as related to the shape and physical characteristics of the orebody. This process demands the consideration of alternatives and the determination of the most economic solution - a research activity.

3. It is with mining equipment and stores that research is largely occupied on these mines. The amount of original research is only small; testing and evaluating various types of equipment already available are the main activities. For this a regular systematic search of technical literature is a necessary activity.

4. An important application of this research technique was the introduction of tungsten carbide tipped drill steel and air-leg mounted rock drills. Eventual use of this equipment was probably inevitable in view of overseas trends, but it fell to mining research to evaluate its application in these mines and to determine the final choice of equipment from available alternatives.

5. Research into underground stores is a continuous process - such items as pully blocks, ropes, hoses and hose couplings, pipes and pipe fittings are constantly under review and alternatives under investigation. The aim is always to obtain maximum economy commensurate with safe operation. A recent example of applied research is a current investigation into the use of ammonium nitrate-fuel oil explosives in small diameter holes drilled for conventional cut and fill stoping.

6. Whilst the types of mining research referred to so far have a specific end-point in the foreseeable future and can thus be evaluated in specific terms, such as increased rate of output or decreased unit cost, there is another aspect of mining research whose end-point cannot be so definite. An example of this is the research into the consolidation of hydraulic stope filling which could achieve considerable advances in mining efficiency and cost. It is not possible at

this stage to consolidat fill economically and research must continue in spite of failure up till now.

7. A further example is the initiation of a research programme in rock mechanics to determine the actual rock stresses underground and to apply the knowledge gained to the design of mine openings so as to minimize the use of timber etc. for ground support. This is basic research with long-range implications.

8. Mining research is aimed at obtaining better efficiency, greater safety and lower costs of production and has both short and long term implications. This can be achieved through improved utilization of men, equipment and materials and by method and equipment studies, establishment and maintenance of standards, and by job evaluation. The Suggestion Scheme provides a means of both fostering and collecting ideas from all employees. Items initiated in the Mining Research Section are often passed over to the Industrial Engineering Section, when the more systematic techniques of Work Study appear desirable.

9. By critical analysis of the methods by which various operations are carried out and of the equipment used, it is generally possible to make improvements which result in the more efficient use of resources of all kinds with consequent savings in costs. A formal technique of analysis known as "Method Study" has been derived for use in this type of work. "Materials Handling" is a special branch of this part of Industrial Engineering and "Cost Analysis" is carried out for the same end.

10. By use of the formal techniques of "Work Measurement" it is possible to establish reasonable or standard times for the performance of various industrial tasks. There are several ways by which work can be measured, each of which has special application to different types of industrial work - the most familiar of these is known as "Time Study" but, similar ends are achieved by use of predetermined motion times, synthesis, analytical estimating, random observations etc. Once standard times for different tasks have been established, it is possible to evolve administrative systems which enable comparison to be made at regular intervals between what is done with what it is possible to do. Indices of efficiency can thus be derived which facilitate the exercise of enlightened control by management.

11. A further use of standard times is in the field of incentive schemes. Once the proper time for a task is known it becomes possible to pay additional wages in equitable proportions to performance by men in excess of standard.

12. By the use of job evaluation it is possible to derive indices for industrial tasks which enable the relative worth of one to be compared to that of another. The availability of these indices is valuable in the derivation of equitable wage and wage incentive schemes.

13. Since Industrial Engineering does its work in all departments of an organization and must be unbiased, it cannot properly belong to any one of them. It is important that it should be separate and report to the top local manager. Of necessity Industrial Engineering staff-members should be carefully chosen for their skill in human relations and their ability to co-operate readily. The Industrial Engineering section itself may be divided into segments with each responsible for

a section of the industrial operation e.g. mining, concentrating, engineering etc., or the section could be divided into functions, some staff becoming expert in methods work, others in standards and others in incentives etc.

14. Examples of the results obtained by these techniques are now described. By use of Method Study and Cost Analysis, it was determined that the most economical way to unload, store and load packaged mine timber on a particular mine was by using a large gantry crane. This resulted in an annual saving of approximately £A20,000. Method Study also revealed an improved method of fabricating pipe hangers for use underground which resulted in a production of 450 hangers per man shift compared with 75 by the original method. By using Time Study it was possible to determine a standard time for the production of a ton of ore from a timber stope. By comparison with what was actually being achieved this allowed management to take action to bring production up to the determined standard. Using Analytical Estimating the standard time for the overhaul of a scraper winch was found to be 40 hours. This knowledge enabled the efficiency of performance of this task to be improved from 37 to 95%.

SELECTIVE OPEN-CUT MINING AT MARY KATHLEEN, AUSTRALIA

15. The Mary Kathleen ore-body near Mt. Isa, Queensland occurs as a series of discontinuous lenses of radioactive ore in a zone of intense alteration in impure lime and silicate rocks. The workable zone occupies a horizontal area about 700 ft x 700 ft. The ore occurrences vary in thickness from a few inches to more than 200 feet, with ore and waste rock occurring in the ratio of approximately 1 to 1.

16. Early recognition of the complex and irregular nature of the ore lenses led to the decision to operate from a large number of low benches with relatively small equipment. This consists of the following machines. One drilling machine with hard metal bit, three drilling machines with 2¾-inch tungsten carbide bits, one 2½-cu yd electric shovel, three 1½-cu yd diesel shovels, one crawler tracked front end loader, sixteen 15-ton quarry-type trucks, four 185 drawbar h.p. bulldozers, one 100 drawbar h.p. tractor, and one 110 h.p. grader.

17. Using this equipment, an average mining labour force of 82 men produce 1,500,000 tons of material annually, comprising: ore, 460,000 tons, waste separated in selective mining operations, 390,000 tons, and overburden, 650,000 tons.

18. Selective mining is practised because the treatment of the ore is expensive and reagent consumption is independent of the uranium content. There is therefore a strong economic incentive to reduce the amount of waste passing into the treatment plant.

19. Each new bench face, as it is exposed by blasting, is examined by samplers with a modified pocket monitor. This beta-gamma detector has been made unidirectional by fitting a lead shield to screen out the effects of radiation from other sources. The boundaries of ore lenses so established are traced out on the face with white paint lines. Ore is identified by the symbols "A" and "B" for high and low grade ore, and waste by "W". The face is then mapped by a geologist.

20. Only one row of 2¾-inch blast holes is drilled 6 ft behind a face, normally 8 ft apart. These holes are drilled to a depth of 27 ft below the bench and are then radiometrically probed and surveyed. The information so obtained is plotted in plan and section to correlate ore intersections and from these plans a selective blasting pattern is planned. Large blasts of ore are rarely possible; nearly all ore production comes from blasts of 2,000 tons or less.

21. The mine foreman, following a long-range excavation schedule, has certain benches and bench areas available to him at any time for current operations. From these areas the treatment plant must be kept supplied with ore. The mine foreman decides what quantity of ore is required and asks for blasting instructions. These are in the form of instructions to blast a certain group of holes and may call for firing some holes part-depth only, or for leaving some gaps in a row of holes, or both. Selective blasting frequently results in ragged or scalloped faces in which case the remainder of the face usually is subsequently broken with toe-hole drilling and blasting.

22. After every primary blast on the ore benches, the broken rock is inspected by a sampler with a geiger counter. Any large lumps of included ore in a waste pile, or waste in an ore pile - more usually the latter - are marked distinctively for removal by a mobile crane and wire rope slings or nip chains. Working two shifts the crane removes a daily average of 150 tons of waste which would otherwise go to the treatment plant.

23. All material from ore benches, as it leaves the open cut, passes through a discriminator. This is a combined weighbridge and radiometric grade assessment station. A loaded Euclid truck halts on the weighbridge platform and its load is scanned by a battery of six geiger tubes shielded from outside influence and fixed to the walls and roof of the building. Impulses from the tubes are integrated and the result read on a dial. The loaded vehicle is then directed by the discriminator operator to its destination, i.e., treatment plant, waste pile, or either of the two stockpiles of marginal ore.

24. Ore delivered to the treatment plant is crushed and screened in order to separate pieces larger than 3 in. and less than 8 in in size. These pieces are sorted into ore and waste fractions by four units, each of which works in the following manner. The lumps of rock are fed from a feeder cone which discharges them in a single line on to a belt conveyor. They are then discharged individually from the belt and fall in front of a scintillometer head which measures the radioactivity of each piece in relation to its area.

25. Rock pieces with a value above a predetermined setting are allowed to fall freely on to a conveyor and join the fine material which did not pass through the sorter. Waste rock pieces with a lesser value are deflected from their free-falling trajectory line by a compressed air blast from three 1¼-in tubes located 14 in below the scintillometer head, and fall on to a conveyor belt for delivery to the waste bin. The average radioactivity of rock discarded by the sorter is very low. This sorting method is applicable in principle to properties of rock other than radioactivity e.g. colour, but application of the principle is difficult.

26. The thanks of the Bureau of Mineral Resources are expressed to the managements of the companies concerned who supplied the information used in this article.

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CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES

Point de l'ordre du jour : A.3.2.2 Italie

POSSIBILITE DE DEDUIRE LE DIAGRAMME DE DISTRIBUTION PAR LA COURBE HYPSOMETRIQUE DU BASSIN VERSANT

Par C. VIPARELLI,
Istituto di Idraulica
e Costruzioni Idrauliche,
Università di Napoli

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

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2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.

3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.

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Possibilité de déduire le diagramme de distribution par la courbe hypsométrique du bassin versant.

VIPARELLI C.

I : La méthode dite rationnelle et le diagramme de distribution

a. Si l'on considère le bassin versant dans une section determinée Z, on définit:

- temps de concentration τ correspondant à un point générique, la durée de trajet d'une particule d'eau entre le point où elle tombe et Z;

- temps de concentration $\overline{\tau}$ du bassin, la valeur de τ au point le plus éloigné de Z;

- lignes isochrones de ruissellement, les lignes lieu des points auxquels correspond une même valeur de τ.

Comme on sait, la méthode dite rationnelle s'appuie à l'hypothèse que les temps de concentration τ sont pratiquement indépendants des intensités des précipitations tombées sur le bassin versant, des débits et du stockage dû aux variations de tirant d'eau dans le réseau hydrographique.

Par conséquent, connaissant l'allure des lignes isochrones de ruissellement, le bassin versant peut être divisé en des zones partielles, $\sigma_1, \sigma_2, \ldots, \sigma_n$, chacune desquelles est limitée par des lignes isochrones successives auxquelles correspondent des valeurs de τ qui diffèrent d'une quantité $\Delta t = \frac{\overline{\tau}}{n}$.

Cela dit, si l'on indique par $h_1, h_2, \ldots, h_K$ les hauteurs moyennes de pluie tombées sur le bassin versant pendant de successifs intervalles de temps $\Delta t = \overline{\tau}/n$, on admet que la contribution donnée à l'écoulement par la pluie tombée pendant l'intervalle j, égale à $\psi_j h_j S$, se partage en n successifs intervalles Δt par la loi $\psi_j h_j S = \psi_j h_j \sigma_1 + \psi_j h_j \sigma_2 + \ldots + \psi_j h_j \sigma_n$, où $\psi_j h_j \sigma_1$ est l'aliquote qui passe par Z au premier Δt, $\psi_j h_j \sigma_2$ celle qui passe au second Δt et ainsi de suite.

En définitive, si l'on appelle hydrogramme élémentaire celui qui est provoqué par la pluie tombée pendant chaque intervalle Δt, on obtient l'hydrogramme de crue en Z en sommant les successifs hydrogrammes élémentaires considérés isolément et décalés l'un par rapport à l'autre pendant le temps d'une quantité égale à Δt.

b. Vu que les pluies qui tombent sur le bassin au commencement de l'averse peuvent, pour la plus grande partie, ne donner aucune contribution à l'hydrogramme de ruissellement, dans les élaborations proposées avec la méthode dite

rationnelle on devrait considérer seulement les hydrogrammes élémentaires qui se rapportent à la durée efficace de la pluie. Au contraire, si, comme on fait d'ordinaire, on introduit aussi les hydrogrammes élémentaires qui correspondent à la phase initiale, on devrait admettre que pour eux ψ_j a des valeurs nulles ou pratiquement nulles. D'une manière analogue, aussi dans les phases successives on devrait tenir compte d'une certaine variabilité de ψ_j qui, pour des averses particulièrement longues et intenses, pourrait résulter, pour les derniers hydrogrammes élémentaires, très proche de l'unité.

c. Si l'on considère n'importe lequel des hydrogrammes élémentaires et si l'on indique avec $\psi_j h_j S$ la contribution aux débits de ruissellement due à la pluie h_j à laquelle il se rapporte, puisque on a que $\psi_j h_j S = \psi_j h_j \sigma_1 + \ldots\ldots, + \psi_j h_j \sigma_n$, on peut dire que, si les hypothèses avancées pour appliquer la méthode rationnelle sont vraies, la contribution $\psi_j h_j S$, que la pluie tombée pendant l'intervalle j donne au débit de ruissellement, se partage entre les n successifs intervalles de temps Δt en des parties proportionelles aux aires $\sigma_1, \sigma_2, \ldots\ldots, \sigma_n$.

Par conséquent, si sur un diagramme cartésien on reporte en abscisse les successifs intervalles de temps Δt et en ordonnée les rapports σ_i/S, disposés en ordre croissant de i, on a la représentation immédiate de la loi selon laquelle dans chaque hydrogramme élémentaire les débits de ruissellement se partagent dans le temps (diagramme de distribution).

On peut tirer un diagramme analogue pour une averse d'intensité constante ayant une durée égale à $2\,\Delta t$ (ou, en général, à un multiple K de Δt), mais pas supérieur à $\overline{r}$, partant de l'hydrogramme composé qu'on déduit en sommant, decalés pendant le temps les 2, (ou K), hydrogrammes élémentaires qui correspondent à une pluie ayant pendant chaque intervalle Δt une intensité égale à celle qu'on considère.

Il est évident, et on peut le vérifier facilement, que, aussi dans ce cas, le nouveau diagramme qu'on obtient résulte indépendant de l'intensité de la pluie, mais il a une hauteur et une longueur de base qui croissent au fur et à mesure que la durée de la pluie croît (ou, ce qui est la même chose, que n croît).

Il est evident aussi que ce type de diagramme coincide avec le diagramme de distribution introduit par voie empirique par Bernard.

On peut, pourtant, conclure que, en partant de la méthode dite rationnelle et en acceptant les hypothèses qu'on y introduit pour en simplifier la mise en oeuvre, on retrouve les mêmes résultats que Sherman et Bernard ont déduit, par voie empirique, en élaborant les relevés pluviométriques et limnimétriques afférents à des crues qui se sont vérifiées dans quelques cours d'eau des Etats Unis. D'un côté cela confirme la validité des hypothèses introduites pour appliquer la méthode rationnelle, de l'autre cela élimine bien des réserves avancées sur la validité générale des méthodes proposées par Sherman et par Bernard sur des bases simplement empiriques.

2 : Diagramme de distribution et courbe hypsométrique

a. D'après ce qu'on a dit au paragraphe Ier, lorsque dans la section Z, où il faut évaluer l'hydrogramme afférent à une averse donnée, on ne dispose pas de relevés limnimétriques, le diagramme de distribution peut être déduit d'une

manière directe en partant de la courbe hypsométrique, qui, comme il est notoire, donne en abscisse la surface du bassin qui se trouve au dessous des cotes d'altitude portées en ordonnées.

En effet, à travers les nombreux exemples dont on parlera au paragraphe suivant, il paraît légitime admettre que les lignes isochrones de ruissellement coincident avec des courbes de niveau et que, si $\bar{H}$ est l'altitude moyenne du bassin rapportée à la cote du fond du lit dans la section Z, les lignes isochrones correspondant à des temps de concentration qui se différencient entre eux d'un intervalle de temps Δt, égal à $\bar{r}/n$, coïncident avec des courbes de niveau distanciées entre elles par des intervalles égaux à $\bar{H}/n$.

Par conséquent, pour évaluer les aires $\sigma_1, \sigma_2 \ldots, \sigma_n$ comprises entre les lignes isochrones d'écoulement qui correspondent à des temps de concentration r égaux respectivement à $1, 2, \ldots, n\,\Delta t$, Δt étant une fraction de $\bar{r}$, en se rapportant à des courbes de niveau placées, par rapport à la cote du fond en Z, à des cotes $1, 2 \ldots, n\,\Delta H$, ΔH étant égal à H/n, on peut admettre que l'aire σ_1, coïncide avec l'aire renfermée dans l'isohypse plus basse 1, l'aire σ_2 avec celle qui est renfermée entre les isohypses 1 e 2, et ainsi de suite.

En définitive, les successives ordonnées du diagramme de distribution pour $t = 1\,\Delta t,\ 2\,\Delta t, \ldots, n\,\Delta t = r$, seront égales respectivement à $\sigma_1/S, \ldots, \sigma_n/S$, S étant la superficie du bassin versant.

3 : Principes suivis dans l'élaboration des données expérimentales

a. Pour vérifier l'hypothèse avancée au paragraphe précédent on a pris en considération des crues qui se sont vérifiées en des bassins de l'Italie Méridionale et Insulaire en ayant soin que la superficie S de ces bassins varie pour une vaste étendue, d'un maximum de quelques milliers de Km^2 à un minimum d'à peu près 10 Kmc.

b. En voie préliminaire, après le dépouillement des relevés publiés par le Service Hydrographique Italien (S.I.I.), pour chaque bassin on a déduit la loi par laquelle les débits du cours d'eau se tarissent pendant les périodes où il n'y a pas de pluie et, par conséquent, pour chaque précipitation on a pu isoler l'hydrogramme de crue (loi de variation dans le temps des débits Q' obtenus comme différence entre les débits Q et les débits de base q) et obtenir la valeur moyenne du coefficient de ruissellement ψ (rapport entre les débits cumulés D et les précipitations A tombées sur le bassin pendant l'averse).

c. Pour évaluer le temps de concentration $\bar{r}$ on a adopté la formule empirique proposée par Giandotti:

$$\bar{r} = \frac{4\sqrt{S} + 1{,}5\,L}{0{,}8\sqrt{\bar{H}}}$$

en prenant pour S, superficie du bassin, et par L, longueur de celui-ci le long du cours d'eau principal du réseau hydrographique, les projections horizontales telles qu'on les déduit de la cartographie; l'altitude moyenne $\bar{H}$, rapportée à la cote du fond du lit à l'exutoire du bassin, a été obtenue par la courbe hypsométrique.

D'ailleurs, la valeur de $\bar{r}$ calculée par la formule de Giandotti est contenue entre les valeurs qu'on obtient d'une manière plus simple en faisant le rapport entre la longueur L du bassin et une vitesse fictive v qui, d'après ce qu'on a constaté aussi pour d'autres bassins, doit rouler autour de 1 m/sec et qui dans aucun cas ne doit dépasser 1,5 m/sec.

d. Pour une valeur donnée de $\bar{r}$, le diagramme de distribution se modifie selon qu'on considère des intervalles partiels $\Delta t = \bar{r}/n$ plus ou moins longs, selon, c'est-à-dire, la valeur qu'on a admise pour n. En tenant compte de cela, les élaborations ont été répétées en donnant pour n des valeurs différentes. On a obtenu des résultats satisfaisants avec Δt = 1/5-1/6 : pour des valeurs plus brèves les discontinuités dans le diagramme reconstruit résultent bien plus accentuées que dans le diagramme relevé, pour des valeurs plus longues il arrive le contraire.

e. Enfin, on a admis que pendant toute la durée de la crue le coefficient de ruissellement ψ_j se maintient constant et égal à la valeur moyenne ψ déduite avec les principes exposés au précedent alinéa b.

f. En reportant en diagramme l'hydrogramme de crue reconstruit pour le comparer avec le diagramme relevé, comme on devait sommer aux débits Q' de l'hydrogramme reconstruit ceux de base q, on a préféré admettre que ces derniers débits sont égaux à ceux qu'on aurait eu dans le cours d'eau si l'averse qui a provoqué la crue ne s'était pas vérifiée. C'est-à-dire on a négligé le fait qu'une portion des eaux météoriques, absorbée par le sol, grossit la nappe qui alimente les débits de base q, de manière que aussi ceux-ci ressentent de la pluie tombée.

4 : Discussion sur les résultats des élaborations

a. Les diagrammes Q' (t) reconstruits ont été toujours adhérents aux diagrammes enregistrés et, en outre, l'adhérence entre les deux diagrammes résulte encore plus satisfaisante que celle qu'on peut obtenir lorsque le diagramme de distribution peut être déduit par voie empirique avec les principes proposés par Sherman et par Bernard.

b. En général, entre diagramme reconstruit et diagramme enregistré on remarque quelques écartements systématiques dont il convient discuter les motifs.

D'abord, les débits reconstruits au commencement de la précipitation sont bien plus grands que les débits enregistrés, tandis que, successivement, ils ont aussi la tendance à en être plus petits. Deuxièmement, le diagramme reconstruit a toujours une certaine anticipation dans le temps par rapport au diagramme enregistré.

Le premier phénomène se justifie facilement par le fait que, contrairement à ce qui arrive dans la réalité, où l'on passe des valeurs initiales de ψ_j pratiquement égales à zéro à des valeurs limite qui s'approchent de un (I-b), dans les élaborations on a admis que la pluie est efficace aux effets de la crue dès le commencement et l'on a établi $\psi_j = \psi$ = const.

Ni l'on ne peut oublier qu'à l'erreur commise en admettant ψ_j = const. se superpose celle d'avoir sommé les débits Q' de l'hydrogramme reconstruit à des débits de base q inférieurs aux débits effectifs (3-f).

Le déphasage dans le temps doit être attribué lui aussi surtout à l'erreur commise en admettant que dans les successifs hydrogrammes élémentaires ψ_j se maintient constant et égal à ψ.

En effet, si, en partant d'un même diagramme de distribution, on considère une pluie d'une durée assez longue et si l'on reconstruit les hydrogrammes de crue qui en sont la conséquence en faisant deux diverses hypothèses à l'égard des valeurs de ψ_j dans les successifs hydrogrammes élémentaires, en admettant dans la première hypothèse que ψ_j se maintient constant et dans la seconde, avec plus d'adhérence à la réalité, que ψ_j passe de la valeur zéro, qu'il a pour les premiers hydrogrammes élémentaires, à des valeurs de plus en plus croissants pour les hydrogrammes successifs, il est facile de vérifier que, à une égale valeur du volume ruisselé, et donc, à une égale valeur du coefficient de ruissellement ψ relatif à la durée entière de la précipitation, l'hydrogramme reconstruit d'après la deuxième hypothèse se présente en retard par rapport à l'hydrogramme reconstruit d'après la première.

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RECENT PROGRESS IN PETROLEUM TECHNOLOGY AND THE PROBLEM OF THE DEVELOPMENT OF REFINERIES

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RECENT PROGRESS IN PETROLEUM TECHNOLOGY AND THE PROBLEM OF THE DEVELOPMENT OF REFINERIES

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Member of the Committee for the New Technique.

1. Recent progress in petroleum technology and some future problems.

a) Among the industries which have most developed in the last 5o years, the oil industry was in the foreground. In the power balance of countries with a highly developed industry, crude oil and natural gas represent today a share exceeding 50%. The recent progress achieved in processing technique by transforming crude oil into products which are widely employed in the conditions of modern life, such as plastics, rubber, fertilizers and others, has still more increased the interest in crude oil.

i) Keeping in mind the fact that on world level the annual total rate of power increase is of about 3%, the present world crude oil production of 1,1 thousand million tons will increase by 1975 to about 2 thousand million. The appearance of new sources in power balance, such as the nuclear, solar and other powers, we reckon that they will not be in a position in the next 3o to 4o years to change to a great extent the importance of liquid fuels, because of investments and of the time necessary for the development of new possibilities of utilization.

ii) Referring to the future demands for oil products, a greater decrease for residual fuels and kerosene, a slight reduction for explosion motor fuels amd a more important increase for fuels and liquified gas, may be expected.

b) It is to be expected that qualitatively improving the characteristics of products which may be profitably obtained will be continued. With gasoline besides the octane number which still remains a principal objective, due to the present trend of increasing the compression ratios, further improvements will certainly be achieved with regard to sulphur and gas contents, volatility, proportion of hydrocarbons, etc.

i) The attention given in the last few years to the production of jet fuels will be accentuated in the future, with a view to realizing higher characteristics, regarding congelation, fumigation point, distillation and stability. For liquid fuels in general , future trends will be directed towards obtaining better characteristics by decreasing the olefines, sulphur and ash contents and by greater chemical stability.

c) Obviously all modifications which will be made regarding the kind and quality of fuels, will be based upon the future development of power generators. Among the internal combustion engines, engines working on the Otto cycle will probably be employed in the next 15-2o years, with modifications improving their present technical characteristics. With Diesel engines, the development of which is still going on, improvements in construction are expected to be obtained which, besides the realization of higher performances, will make it possible to consume fuels of wider specifications. As regards the new types of power generators, an extension of gas-turbine motors, used in aviation, road machines and of free-piston motors for fixed installations is expected.

The principle objective in the construction of new types of engines is to obtain better performances and the possibility to consume cheaper fuels of less severe specification than the present ones.

d.) Crude oil refineries had to closely comply with the demands of fuel consumers, and this requires a continuous improvement of processing methods from the simple process of physical separation by groups of crude oil into hydrocarbons, to complex, chemical processes of structural molecular modification, especially by catalytic methods.

e.) With primary refining methods, the technological performances have been improved by the use of better heating and fractionating equipment, by combined large capacity installations and by automation, thus realizing savings of investments and of running expenses at the same time chemical and electrical treatment of crude oil, resulted in longer service cycles of refining equipment.

f.) In refining products, catalytic hydrogenation methods and electrical treating have been extended, and improvements in extraction methods by selective solvents have been achieved.

g.) The turning to account of residual products remains an important aim in the refining of crude oil, and, besides the known methods of thermo-cracking and coking, the recent appearance of hydrocracking, offering the advantage of great flexibility, will contribute to solving this problem. The high hydrogen consumption supplied at the present time, in a great proportion by catalytic reforming will have to be provided by independent means and at a low price.

h.) Regarding the catalytic processes for production of gasoline, catalytic cracking has, in some countries, exceeded 40% of crude oil refining, and in the following years will probably occupy a still more important place, so long as the present demand for light products will be maintained at the present level.

i.) In recent years, catalytic reforming has had the widest extension due to the performance achieved in increasing the octane number, and to the production of aromatic hydrocarbons, attaining about 20% of the refined crude oil. This method is in full progress due to the advantages offered. Among other catalytic methods which have lately been applied in crude oil refineries, and have development prospects in the future, has been the normal isomerization of paraffins, for the production of components with high octane numbers.

The large possibilities of petrochemistry have determined important modifications in the refining technique, and it is expected that in the future such modifications will be obtained at a growing rate. Thus metaxyle isomerization plants have been set up in refineries, for the production of ortho and paraxylon and of hydrodealkylation of alkylnaphtalenes and of toluene for obtaining petrochemical naphthalene and benzene.

j.) The list of petrochemical products is long and is continually becoming longer and by a realistic estimation, in 1965 it will come to more than 40% of the entire chemical industry. At present nearly 70% of the rubbers and over 85% of the aliphatic chemicals are produced from oil and natural gas, while certain products such as isoprophylic alcohol, butadiene and methylformaldehyde are obtained exclusively from crude oil. The numerous examples which may be given show the importance of crude oil for the industry.

2. Rumania's experience in the development of the crude oil refining industry related to the development of extraction and to the requirements for high quality refinery products

a) Rumania is among the first oil producing countries of the world.

The occurence of crude oil and its utilization for various purposes is known from documents dating prior to the XVth century, its organized exploitation , however started only much later, and in 1957, the Rumanian People's Republic celebrated the 100th anniversary of its oil industry. This long-standing activity has meant a rich experience in the extraction and refining of crude oil and has created a strong tradition within this industry.

a) The Rumanian crude oil production, which in 1936 amounted to 8,7 million tons/year decreased until 1944 to 3,6 million tons, due to the exploitation in poor technical and economic conditions, and to destructions caused by war. During that period of a total of 59 petroleum refineries only 12 had adequate technical equipment and the remainder were working in rudimentary conditions. A large quantity of crude oil was exported as such.

b. After the second world war by its passing into state property, the oil industry, reorganized on new bases and endowed with up-to-date technical equipment is characterized by an accelerated development in the framework of the planned development of the whole national economy. In the oil processing sector the principal objectives have been the rebuilding of refineries destroyed by war, and their concentration of refining into great production units, their territorial repartition according to the industrial development, the supply of refineries with modern refining system and the raising of economic efficiency in crude oil refining.

i. In the first stage new refining centres were set up, existing refineries were rebuilt and their capacity increased in view of the steady raise of the production level, and smaller refineries with low production and economic capacities were shut down. The second stage is characterized by the endowing refineries with the most up-to-date methods and equipment in order to obtain new high quality products, and for the development of petrochemistry. For the production of lubricating oils new, large capacity, complex plants for selective solventation were built, thus increasing the yearly output of lubricants of high viscosity index. The turning to account of residual products has been realized by coking methods, viscosity reduction and hydrocracking, especially concerning the production of medium distillates and fuels for Diesel engines, and by hydrofyning plants for improving the quality of these products. Due to these results the percentage of residual products decreased from over 40% in 1938 to about 25% at present, while the percentage of motor fuel increased from 12% to over 25%. Among catalytic methods for increasing the octane number, catalytic cracking plants of the liquid type ,and large catalytic reforming plants for the production of high quality gasoline and individual C_6, C_7 and C_8 aromatic hydrocarbons, were set up. The non-economic aspect until 1948 of crude oil refining based on the consumption of refinery gas, was solved by supplying the refineries with gas recovery and fractionating equipment, and the utilization of the refinery gas for petrochemistry or domestic purposes.

c. The introduction of new methods for improving the quality of products has brought about an increase of the octane number of 25-3o points in fuels for engines while the viscosity index of lubricating oils has increased from about 4o to more than 90 DD. Likewise, the quality of gasolines and fuel oils has been improved by decreasing their sulphur content and by increasing their chemical stability; congelation points of lubricants and of fuels went down, and generally, the competitive value of all products increased.Simultaneously with the deepening of crude oil refining , the production of special products has been extended, such as naphtenic acids, surfactants additives for fuels, lubricants, mercaptans, cresilic acids, wood impregnation fluids, etc. Due to rational refining of crude oil, the economic efficiency of that industry has increased; in a period of 6 years an increase of over 40% of its value has been achieved, while labour productivity increased by more than 25% as compared to the past.

i) At the same time with the development of crude oil refining, a great petrochemical industry has been created in Rumania, by the setting up of combined works for the production of synthetic rubber, plastics, synthetic threads and fibres and other products.

d) The difficulties, encountered immediately after the war in the realization of the reconstruction and modernization plan of the refining industry, due to the lack of a metallurgical and engineering industry for refinery equipment, have been solved by commissioning some works, endowed with modern technical equipment. As compared to the past, when Rumania had to import most of its refinery equipment, at the present time the production of our oil industry equipment engineering works set up in the period of socialist industrialization supplies the internal necessities, and an appreciable tonnage remains for export to other countries. In the post-war period, in order to assist the oil industry, research institutes and specialized laboratories for the study and experimenting of new crude oil refining and petrochemical problems as well as designing organizations have been established. For training petroleum engineers, an institute for higher training was set up, including all technical specialities required by the oil and gas industry, while for the training of lower technical refinery personnel, schools for technicians with refining as speciality were also established.

e) The improvement in working and living conditions for workers, one of the main concerns of the Rumanian state, has limited the working hours and has created the possibility for workers of spending their leisure hours in spas and health resorts or in sanatoriums. Special attention is given to labour protection and to safety technique, for increasing labour safety and reducing the number of accidents at work.

3. Considerations concerning the technical and economic conditions which permit to evaluate the possibilities of petroleum refineries

a) The construction of refineries in countries with oil deposits is an essential condition for their economic development, based on a rational turning to account of the resources at their disposal. For developing countries, it is advisable that the setting up of refineries be attentively correlated to current consumption requirements of oil products, to probable requirements for the following years, for internal and international markets, to the specific industrial development possibilities and to requirements of the raising living standard of the population. In drawing up plans for the construction of refineries in countries with a developing industry, the study of conditions connected with possibility of uniformly supplying refineries with sufficient quantities of raw materials, is necessary. We also consider it advisable that possibilities be kept in mind of setting up refineries with large capacities, which should be in position to turn out a range of products required by the sectors consuming fuels, gasolines, fuel oils, lubricants, Diesel fuels, as well as having up-to-date plants for coking, hydrofining, cracking and catalytic reforming, in order to ensure the production of raw materials for other important industries, especially detergents, fertilizers, bases for insecticides, liquefied gas, road-bitumen, etc. Wherever local economic conditions impose it, the setting up of refineries may of course be realized in stages, providing from the beginning the facilities required for the final phase, in view of the economically satisfactory realization of auxiliary installations.

b) Regarding the siting of refineries, it is economically advisable that they be placed near the source of raw materials, or at distances from which raw materials may be economically transported, in regions with transport facilities, waterways, and in the vicinity of consumption centres.

For ensuring an economic siting, preliminary studies are necessary taking into consideration the most advantageous conditions and, at the same time, creating the possibility of making use of local resources, so as to reduce investments and exploitation expenses.

c) Labour necessary to the crude oil refining industry is an important problem, and the fact that special qualifications are required, makes it necessary that a sufficient number of workers, foremen and engineers be trained in time, in schools and in the factories existing in more advanced countries thus becoming able to take over the running control of the refinery, when the installation is completed.

i) Experience has shown that for medium and higher personnel, a practice of about 1-2 years is necessary , for mastering sufficiently the necessary knowledge.

ii) In the case of a collaboration between countries for setting up refineries in countries which have no industries of their own, it seems advisable that this task be realized with the aid of the constructing country, which should facilitate the training of the necessary staff on the basis of certain theoretical and practical educational plans.

d) Regarding the possibility of setting up refineries in developing countries; the designing, delivery and mounting of equipment and putting the respective plant into commission, should be kept in mind in the general contracts between countries.

i) The method used sometimes of a single general contractor, has proved effective, this contractor bearing full responsibility for the entire installation, and being thus in a position to ensure the realization of the parameters stipulated in the design and the contract.

ii) In case there is no general contractor for the entire equipment, contracts may evidently be signed with various contractors from the same or from different countries, the construction of the refinery remaining in charge of the beneficiary country, the contractors giving technical assistance in mounting the refinery and putting it into commission. In this case, other tasks reverting to contractors should be the training of the exploitation staff, and the upkeepers of the equipment.

iii) Technical problems regarding designing, production of equipment, constructions, etc. should be provided for in accordance with international norms (I.S.O), or to other specified norms.

e) Construction terms for refineries , which represent a contractual obligation between contractors and beneficiaries are dependent on local conditions: experience has shown that the normal completion term for a refinery is of 22-30 months from the signing of the contract.

4. Rumania's realizations in other countries

a) By the discovery of new oil fields, at which the Rumanian People's Republic has also collaborated, the Indian state has accelerated the construction of state refineries at Gauhati and Barauni. The Gauhati refinery, with a yearly capacity of 750.000 tons, with an extension possibility to over one million tons entered into commission in 1962, was designed and constructed by Rumania, on the basis of bilateral agreements. For placing the refinery, establishing the capacity and treating profile, preliminary technical economic studies by Rumanian and Indian experts were necessary. To satisfy the local consumption of oil products and to ensure future industrial development were basic criteria for selecting the capacity and profile of the refinery. The technological scheme of the refinery comprises atmospheric distillation, coking, kerosene solventing with sulphur dioxide,

gas recovering and fractionating plants, and auxiliary installations for refining the products. The refinery has all auxiliary installations, such as tank farms, pumping stations, loading facilities, laboratories etc., as well as a thermo-electrical power station. The mounting of the refinery was carried out by Indian construction enterprises, and the putting into commission with the collaboration of Rumanian technical personnel.

i) The main difficulties encountered in the designing and construction of the refinery was the high seismicity of the region, the weak resistance of the ground, the industrial water supply and the evacuation of residual water, the rainfalls, specific to tropical regions, and the labour supply for construction.

b) The training of the Indian technical personnel for running of the refinery was the object of a special attention in the framework of Rumanian-Indian collaboration. Indian engineers and technicians were practically and theoretically trained, for more than two years, in Rumanian petroleum institutes and refineries, while Rumanian specialists sent to India have organized initiation courses regarding operative technique, maintenance and repairs, and the prevention of accidents in petroleum refineries.

5. Conclusion

By the development of oil industry on the line of using complex and complete technological processes, the possibilities of employing a still wider range of the products obtained are considerably growing and on the production of special high quality fuels, are ensured on the one hand and, on the other, a particularly important source of raw materials for the petrochemical industry is thus created. We consider that by such an orientation, countries in process of industrialization which possess crude oil deposits, will be in a position to develop powerful, natural oil and petrochemical industries, thus rationally turning to account an important source of raw materials.

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